AD-776 360

# ENGINEERING FLIGHT TEST-AH-1G HELICOPTER WITH MODEL 212 TAIL ROTOR. PART II. PERFORMANCE AND HANDLING QUALITIES

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Army Aviation Systems Test Activity
Edwards Air Force Base, California

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Lateral-directional oscillation
Blade angle limits

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The United States Army Aviation Systems Test Activity conducted a limited performance and handling qualities evaluation of the AH-1G helicopter with a Bell Helicopter Company commercial Model 212 tail rotor installed. This installation included changes to the pitch links and pitch control tube to accommodate the Model 212 tail rotor; however, the remaining components of the tail rotor drive system were standard AH-1G items. The evaluation was performed during the period 29 May to 7 August 1973 at Edwards Air Force Base, Bakersfield, and Bishop.

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20. Abstract

California. Data were obtained for comparison with the tractor tail rotor (Model 801) configured AH-1G. Twenty-seven productive flight hours were required for this evaluation. As compared with the tractor tail rotor the Model 212 tail rotor configured AH-1G required slightly less power to hover. The hover ceiling (even when limited by a 10-percent directional control margin) was higher with the Model 212 tail rotor. Level flight performance was essentially unchanged. The AH-1G/Model 212 configuration provided a significant improvement in directional control during hover and right sideward flight at high gross weights and density altitudes. Hovering turns were arrested more rapidly and with less tail rotor drive train loading; however, tail rotor component horsepower limits may be exceeded during abrupt full left pedal inputs. Static longitudinal and lateral-directional stability characteristics are essentially unchanged by the Model 212 modification. A shortcoming was the undesirable lateral-directional oscillation above 120 knots. Further testing should be conducted to determine the effects of increasing the tail rotor maximum blade angle limits.

AD776 360

# ERRATA

## USAASTA PROJECT NO. 72-30

## FINAL REPORT

## ENGINEERING FLIGHT TEST

## AH-1G HELICOPTER WITH MODEL 212 TAIL ROTOR

## PART II

## PERFORMANCE AND HANDLING QUALITIES

Page 13, table 2, footnote 1, line 4: Change to read

Outside air temperature: 23.5°C

Page 35: Add the following paragraph

**Translational Flight**

20. Translational handling qualities were investigated by conducting tests at various combinations of wind azimuth and airspeed (TAS). A pace vehicle with a calibrated speedometer was used as a reference when attempting to stabilize the helicopter at the desired airspeed and azimuth. Ambient wind velocity and direction were incorporated into the analysis when determining airspeed and wind azimuth.

Where:

TAS = Vectorial sum of ground speed and wind velocity

Azimuth = Vectorial sum of ground speed direction and wind velocity direction with respect to aircraft heading

Page 37, line 22: Change to read

Roll angular acceleration 1 deg/sec$^2$

Page 116, Figure 76: Under column heading titled "Flight Condition" add the following word

Level



12

# TABLE OF CONTENTS

Page

APPENDIXES

# INTRODUCTION

## BACKGROUND

1. Results of Phase D testing of the AH-1G helicopter by the United States Army Aviation Systems Test Activity (USAASTA) showed that directional control power was inadequate within a large portion of the proposed low-speed in-ground-effect (IGE) maneuver envelope (ref 1, app A). Subsequent testing with the tractor tail rotor showed continuing directional control problems and significant flight and gross weight restrictions (ref 2). The USAASTA was directed by the United States Army Aviation Systems Command (AVSCOM) to evaluate the AH-1G helicopter with the Model 212 tail rotor (app B).

## TEST OBJECTIVES

2. The objectives of the AH-1G/Model 212 tail rotor evaluation were as follows:

a. To conduct a tail boom load survey with the Model 212 tail rotor.

b. To conduct a limited performance evaluation of the Model 212 tail rotor.

c. To obtain quantitative and qualitative stability and control flight test data on the AH-1G in the Model 212 tail rotor configuration.

d. To determine the instrument-flight-rules (IFR) capability of the AH-1G helicopter with the Model 212 tail rotor.

3. This report presents the results of the performance and handling qualities tests (paras 2b and c). Results of the load survey (para 2a) are reported in USAASTA Final Report No. 72-30, Part I (ref 3, app A). The IFR evaluation with this tail rotor has been delayed for an indefinite period of time because of a requirement to use the instrumented tail rotor in other tests by the prime contractor.

## DESCRIPTION

4. The test helicopter, AH-1G serial number 71-20985, is a production aircraft with a tractor tail rotor. The AH-1G features two-place tandem seating, and two-bladed main and tail rotors. A three-axis stability and control augmentation system (SCAS) is provided. The power plant is a Lycoming T53-L-13B rated at 1400 shaft horsepower (shp) at sea-level, standard-day, static conditions. Installed in the AH-1G, the engine is limited to 1100 shp by the main transmission torque limit. The maximum gross weight of the AH-1G is 9500 pounds. The Model 212 tail rotor, installed for this evaluation, is a flex-beam rotor which is standard on the Bell Model 212 commercial helicopter. Compared to the tractor tail rotor

(Model 801), the Model 212 tail rotor has an increased chord from 8.4 inches to 11.5 inches, and a cambered airfoil blade section. The tail rotor drive system included standard AH-1G components except for the changes to the pitch links and pitch control tube necessary to accommodate the Model 212 tail rotor. In order to remain within the standard AH-1G tail rotor drive train torque rating, tie-down tests were performed to determine the maximum referred tail rotor shp of the Model 801 tail rotor and this limit was established as the desired maximum referred horsepower setting for the Model 212 tail rotor. The resulting tail rotor collective pitch stop settings for the Model 212 installation occur at blade angles of 17.7 degrees (full left pedal) and 10.3 degrees (full right pedal). A description of the tractor and the Model 212 tail rotors is presented in appendix C. The Model 801 tail rotor is more fully described in Bell Helicopter Company Engineering Change Proposal AH-1G 350 (ref 5, app A). A more detailed description of the AH-1G helicopter is contained in the operator's manual (ref 6). Photographs of the Model 801 and 212 tail rotor installations are presented in appendix D.

## TEST SCOPE

5. The AH-1G/Model 212 tail rotor performance and handling qualities tests were conducted in California at Bakersfield (elevation 420 feet), Edward Air Force Base (elevation 2302 feet), Bishop (elevation 4112 feet), and Coyote Flats (elevation 9500 feet) from 29 May 1973 to 7 August 1973. During this evaluation, 44 flights were conducted for a total of 42 flight hours, of which 27 were productive. The two configurations tested were clean (no external stores), and Hog (two XM159C pods on each wing). Forward flight testing was accomplished at approximately 8000 and 9000 pounds, aft center of gravity (cg), 5000 feet density altitude, 324 rpm main rotor speed, airspeeds up to maximum for level flight, and with the SCAS ON. In addition, hover and low-speed testing were conducted at approximately 2000 feet and 11,000 feet density altitude. The flight restrictions and operating limitations applicable to this evaluation are contained in the operator's manual (ref 6, app A), as modified by the safety-of-flight release (refs 7 and 8).

## METHODS OF TEST

6. Established flight test techniques and data reduction procedures were used (refs 9 and 10, app A). The test methods are briefly described in the Results and Discussion section of this report. Test results were compared with the results of testing conducted on the AH-1G with the Model 801 tail rotor (ref 2) and the applicable portions of military specification MIL-H-8501A (ref 11). A Handling Qualities Rating Scale (HQRS) was used to augment pilot comments relative to handling qualities (app E). Data reduction techniques utilized are described in appendix F.

7. The flight test data were obtained from test instrumentation displayed on the pilot and copilot/gunner panels and recorded on magnetic tape. A detailed listing of test instrumentation is contained in appendix G.

## CHRONOLOGY

8. Chronology of the AH-1G/Model 212 tail rotor evaluation is as follows:

| | | | |
|---|---|---|---|
| Test directive received | 27 | July | 1972 |
| Test aircraft received | 9 | May | 1973 |
| Test began | 29 | May | 1973 |
| Test terminated | 7 | August | 1973 |

# RESULTS AND DISCUSSION

## GENERAL

9. A limited evaluation of the performance and handling qualities of the AH-1G helicopter with a Model 212 tail rotor installed was conducted. Performance testing was limited to hover and level flight. Handling qualities were evaluated during hover, translational flight, and forward flight. Static and dynamic stability and controllability tests were performed. A slight decrease in power required was noted for hovering flight with the Model 212 tail rotor installed as compared with the tractor (Model 801) tail rotor. Directional control limits the hover ceiling of the AH-1G IGE and out of ground effect (OGE); however, an increase in hover ceiling was realized with the Model 212 tail rotor configuration. The AH-1G/Model 212 configuration provides a significant improvement in directional control during hover and right sideward flight at high gross weights and density altitudes. Hovering turns were arrested more rapidly and with less tail rotor power than the tractor tail rotor AH-1G; however, tail rotor power train horsepower limits may be exceeded with abrupt full left pedal inputs. One shortcoming was identified: an undesirable lateral-directional oscillation above 120 knots. Static longitudinal and lateral-directional stability characteristics are essentially unchanged. Further testing should be conducted to determine the effects of increasing tail rotor blade angle limits.

## PERFORMANCE

### General

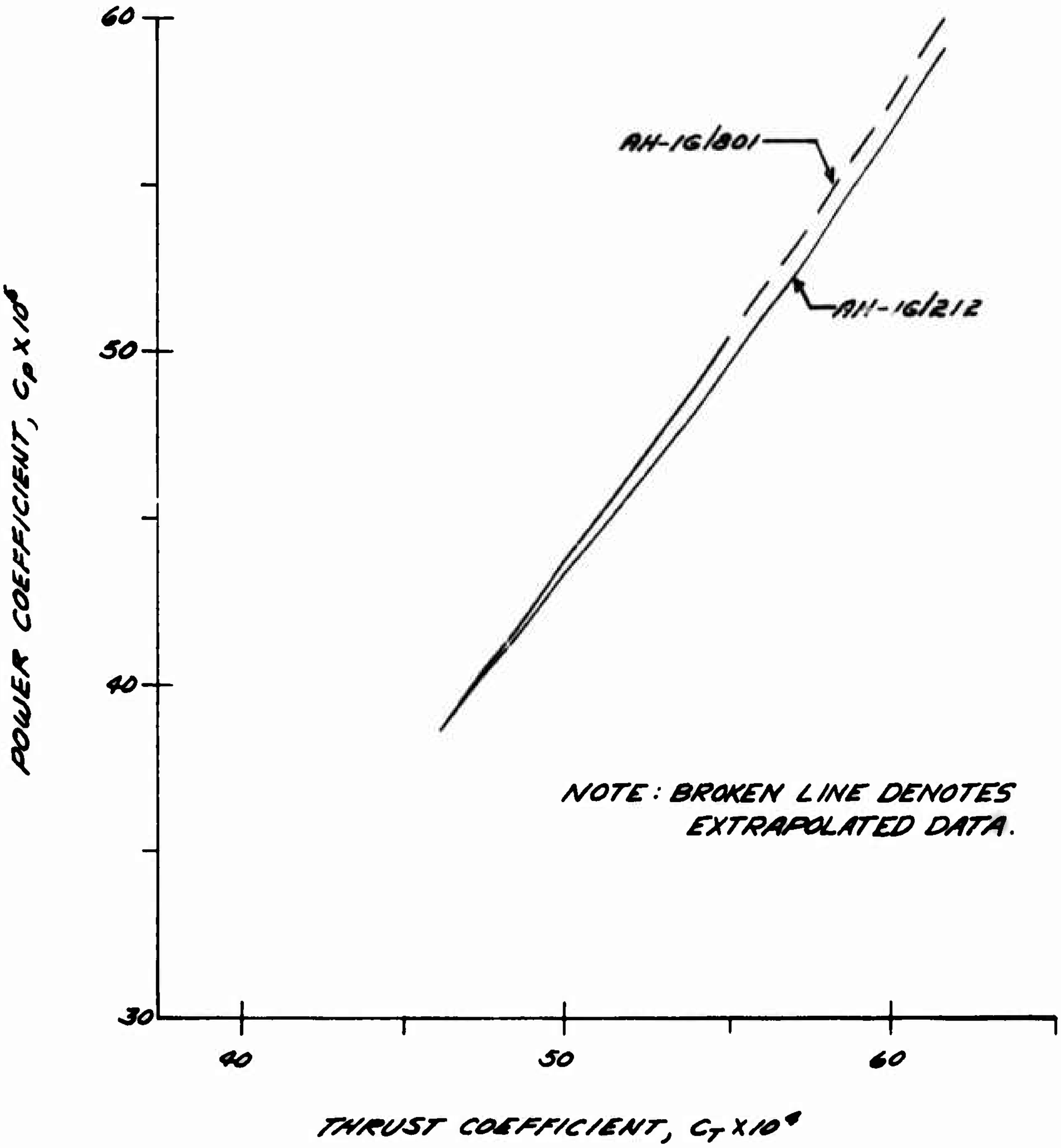
10. Hover performance and level flight performance tests were conducted during this evaluation. The hover performance data indicate a slight decrease in power required to hover with the Model 212 tail rotor installed. Directional control margin limited hover ceiling but was less stringent with the Model 212 tail rotor than with the Model 801 tail rotor. There was no significant change in the level flight performance of the AH-1G with the Model 212 tail rotor installed.

### Hover Performance

11. Hover performance testing was conducted IGE at a skid height of 5 feet and OGE at two elevations, 2302 feet and 9500 feet. The tethered hover method was used to obtain the majority of the hover performance data and a limited amount of free flight hovering was accomplished to verify the results. A cargo hook arrangement incorporating a calibrated load cell was attached to the helicopter as shown in photo 1, appendix D. Tests were performed within a rotor speed range of 294 to 324 rpm. The results of the hover performance tests are presented in figures 1 through 8, appendix H. Test data indicate a slight decrease in power required to hover with the Model 212 tail rotor configuration when compared with the Model 801 tail rotor, as shown in figure A.

FIGURE A

OGE HOVER PERFORMANCE COMPARISON



12. Hover capability for both a standard day and a hot day (35° C at all altitudes) were determined from figures 1, 2, and 9, appendix H. On a hot day, the AH-1G helicopter with the Model 212 tail rotor installed can hover at a skid height of 5 feet IGE at 1660 feet at the maximum gross weight of 9500 pounds, while the gross weight must be reduced to 9100 pounds at sea level to hover OGE. Hover capability IGE with the Model 801 tail rotor at maximum gross weight was 1600 feet, and the maximum gross weight for OGE hover at sea level was 9070 pounds. The standard-day hover ceiling, based on maximum engine power available, was 9680 feet at a 5-foot skid height IGE and 700 feet OGE at 9500 pounds with the Model 212 tail rotor as compared to 9580 feet and 340 feet, respectively, with the Model 801. Test data indicate a slight increase in hover performance with the Model 212 tail rotor configuration when compared with the Model 801 tail rotor as shown in figure B.

13. To satisfy the directional control requirement intent of MIL-H-8501A, a minimum of 10 percent of full directional control remaining has been established as a limit. This directional control requirement limits standard-day hovering performance of both the Model 212 and 801 tail rotor configured AH-1G helicopters. The effects of this limit on hovering performance are shown in figure B. As shown in the figure, this reduced IGE 5-foot skid height hover capability, at a maximum gross weight of 9500 pounds, occurs at altitudes above 8200 feet in the Model 212 configuration as compared to 7720 feet in the Model 801 configuration. The altitude at which maximum OGE hovering performance becomes limited by the 10-percent tail rotor control restriction was 7940 feet for the Model 801 and 12,700 feet for the Model 212, irrespective of gross weight. At a gross weight of 7860 pounds, the OGE hover capability was increased from 11,520 to 12,700 feet with the Model 212 tail rotor installed. This altitude increase corresponds to an increase in net payload capability of approximately 280 pounds at altitudes above 12,700 feet.

### Level Flight Performance

14. Level flight performance tests were conducted in conjunction with control position characteristics tests to facilitate testing. Tests were conducted at gross weights of 8000 and 9000 pounds in the Hog configuration. The results are presented in figures 10 and 11, appendix H. Data were obtained in stabilized level flight at the desired gross weight/density altitude ratio ($W/\sigma$). The data indicate no essential difference between the level flight performance of the Model 212 and Model 801 tail rotor configured AH-1G helicopters.

## HANDLING QUALITIES

### General

15. The handling qualities of the AH-1G helicopter with the Model 212 tail rotor installed were evaluated under a variety of operating conditions. The AH-1G/Model 212 configuration provides a significant improvement in directional

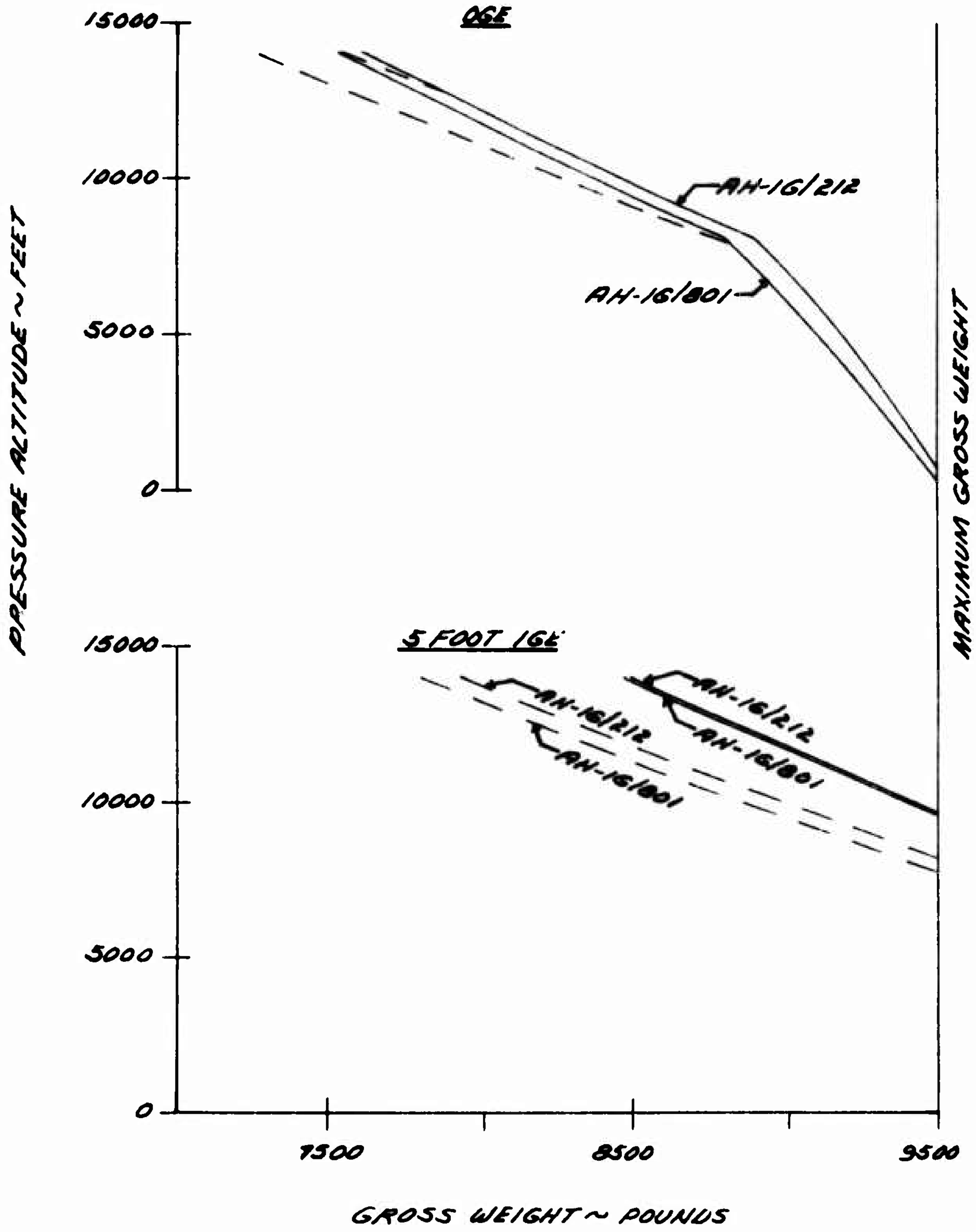
FIGURE B

HOVER CAPABILITY COMPARISON

STANDARD DAY

NOTES:

1. SOLID LINE REPRESENTS HOVER CEILING BASED UPON MAXIMUM ENGINE POWER AVAILABLE.
2. BROKEN LINE REPRESENTS HOVER CEILING BASED UPON 10 PERCENT DIRECTIONAL CONTROL MARGIN AVAILABLE.



control during low-speed flight at high gross weights and density altitudes. Hovering turns can be arrested more rapidly with lower tail rotor power train loads than the Model 801 tail rotor configured AH-1G; however, tail rotor horsepower limits may be exceeded by abrupt full left pedal application. The AH-1G/Model 212 undesirable lateral-directional gust response at airspeeds above 120 knots calibrated airspeed (KCAS) is a shortcoming. Static longitudinal and lateral-directional stability are essentially unchanged. Further testing should be conducted to determine the effects of increasing tail rotor blade angles beyond the current 17.7-degree limit.

## Control System Characteristics

16. Control system characteristics were measured in a static condition on the ground with the engine and rotor stopped. Electrical and hydraulic power were furnished by external sources. Both aircraft hydraulic systems were pressurized. Control displacement and force measurements were recorded on magnetic tape. Control force as a function of displacement is presented in figures 12 through 15, appendix H. The cyclic pitch control pattern is presented in figure 16. Control system characteristics in flight were essentially the same as those determined under the above described static test conditions.

17. The results of the control system evaluation, as summarized in table 1 and compared with the requirements of MIL-H-8501A, are essentially the same as the Model 801 tail rotor configured AH-1G. Although the control forces generally exceed the specification requirements, they are satisfactory.

Table 1. Control System Characteristics.[1]

| Control | Breakout Force Including Friction (lb) | | Control Force Gradient (lb/in.) | | Maximum Control Force (lb) | |
|---|---|---|---|---|---|---|
| | Test Results | MIL-H-8501A Maximum | Test Results | MIL-H-8501A Maximum | Test Results | MIL-H-8501A Maximum |
| Longitudinal | 2.5 | 1.5 | 2.5 | 2 | 11 | 8 |
| Lateral | 2.5 | 1.5 | 1.8 | 2 | 11.5 | 7 |
| Directional | 2.5 | 7 | N/A | N/A | 34 | 15 |
| Collective | 7.5 | 3 | N/A | N/A | 13 | 7 |

[1]Force trim: ON.
Control force measured at center of pilot grip and pedal.

### Control Positions in Trimmed Forward Flight

18. Control positions were determined in trimmed level flight, climbs, and autorotations with the aircraft stabilized at zero sideslip. Data were recorded at airspeeds from 45 KCAS to the maximum airspeed for level flight ($V_H$) at 8000 and 9000 pounds gross weight at a 5000-foot density altitude. Figures 17 through 19, appendix H, present the results of these tests.

19. Comparison of Model 212 test results with the Model 801 tail rotor (ref 2, app A) shows that for all airspeeds tested the left pedal requirement for stabilized level flight was less with the Model 212 tail rotor. This difference was minimum (approximately 0.2 inch) at 74 KCAS and increased at higher and lower airspeeds up to approximately 0.3 inch at 65 and 125 KCAS. The Model 212 tail rotor required less directional trim shift with increase in airspeed in level flight. Lateral control positions of the AH-1G/212 generally parallel the lateral control positions of the Model 801 tail rotor configured AH-1G but are approximately 1 inch to the right. This yields a nearly centered cyclic control in level flight throughout the airspeed range tested. In forward flight these differences were barely noticeable. In climbs and autorotations, the Model 212 tail rotor configuration generally exhibited the same trim position characteristics as the Model 801.

### Static Longitudinal Stability

20. Static longitudinal stability characteristics were evaluated in level flight at 75, 95, and 120 KCAS and in climbs and autorotations at 75 KCAS. Tests were conducted at 8500 pounds and a 5000-foot density altitude at an aft cg with SCAS ON. For each test condition the aircraft was trimmed in steady-heading, zero sideslip flight. With the collective control held fixed, the aircraft was stabilized at incremental speeds greater and less than the trim speed. Test results are presented in figures 20 and 21, appendix H.

21. Static longitudinal stability, as indicated by the variation of longitudinal control position with airspeed, was positive at all airspeeds and conditions tested, with essentially the same gradient as the standard AH-1G. Within the scope of this test, the static longitudinal stability of the AH-1G/212 helicopter is essentially the same as the standard AH-1G and is satisfactory.

### Static Lateral-Directional Stability

22. Static lateral-directional stability characteristics of the AH-1G helicopter with Model 212 tail rotor installed were evaluated in level flight, climbs, and autorotations at 8500 pounds, a 5000-foot density altitude, and an aft cg. The aircraft was trimmed in zero sideslip flight at the desired conditions. With the collective control fixed, the aircraft was then stabilized at incremental sideslip angles on both sides of trim to the limits of the sideslip envelope. Test results are presented in figures 22 through 24, appendix H.

23. Static directional stability, as indicated by the variation of directional control position with sideslip, was positive and essentially linear at all test airspeeds and conditions. This gradient increased with increasing airspeed. Dihedral effect, as indicated by the variation of lateral control position with sideslip, was positive and essentially linear at all test airspeeds. Pitch with sideslip occurred at all trim airspeeds and was similar to the Model 801 configuration. The side-force characteristic, as indicated by the variation of bank angle with sideslip, was positive for all test conditions, and essentially the same as the standard AH-1G. The static lateral-directional stability characteristics of the AH-1G/212 helicopter are similar to the Model 801 tail rotor configured AH-lG and are satisfactory.

**Dynamic Stability**

24. Lateral and directional dynamic stability tests were conducted with SCAS ON and OFF in forward flight to evaluate the short-term response of the aircraft following a gust disturbance. Tests were conducted at 8500 pounds, a 5000-foot density altitude, and aft cg. Data were recorded during 1-inch lateral and directional pulse inputs and during releases from steady-heading sideslips. A summary of dynamic stability characteristics is presented in figure 25, appendix H. Typical time histories of aircraft response are presented in figures 26 through 31.

25. Aircraft response to lateral and directional pulse inputs with SCAS ON was similar to the standard AH-1G. Lateral response was essentially deadbeat and directional response was moderately damped with no apparent tendency for small residual yaw oscillations. At 75 and 95 KCAS, the AH-1G/212 lateral-directional (Dutch roll) response to a release from a steady-heading sideslip was a lightly damped oscillation, returning to stabilized flight in approximately two cycles. At 121 and 131 KCAS, the aircraft rolled to nearly wings level, hesitated, then rolled rapidly away from the original bank. The aircraft then exhibited one lightly damped roll cycle and slowly returned to trim. Moderate pilot compensation would be required while flying in turbulence to maintain balanced flight above 120 KCAS (HQRS 4). The AH-1G/212 lateral-directional response at airspeeds above 120 KCAS following a gust disturbance is a shortcoming. Further testing should be conducted to determine airspeed and power combinations which produce acceptable lateral-directional handling qualities during flight in turbulence.

26. A summary of lateral and directional dynamic stability characteristics with SCAS OFF is presented in table 2 and typical time histories are presented in figures 30 and 31, appendix H. The Model 801 configuration was qualitatively evaluated as being essentially the same as the standard AH-1G (ref 2, app A). Lateral and directional damping with the Model 212 tail rotor was essentially the same as the standard AH-1G.

Table 2. Lateral and Directional Dynamic Stability Characteristics.[1]

| Control Axis | Average Gross Weight (lb) | Calibrated Airspeed (kt) | Average Damping Ratio | Description |
|---|---|---|---|---|
| Directional | 8600 | 94 | 0.24 | Light damping |
| Lateral | 8800 | 94 | 0.25 | |
| Directional | 8400 | 121 | 0.23 | |
| Lateral | 8500 | 121 | 0.23 | |

[1]SCAS OFF.
Center-of-gravity location: 199.5 inches.
Density altitude: 5000 feet.
Outside air temperature: 23,5°C.
Rotor speed: 324 rpm.
Configuration: Hog.

## Controllability

27. Controllability characteristics with the SCAS ON and OFF were evaluated in hover and forward flight. Tests were conducted at 7500 and 8500 pounds in the Hog configuration at an aft cg and at density altitudes of 2000, 5000, and 11,000 feet. Single-axis control step inputs were applied to the lateral-directional controls, using mechanical fixtures to obtain the desired control input size. The control inputs were held constant and the subsequent angular displacement (control power), angular rate (control response), and angular acceleration (control sensitivity) were measured. The results of these tests are presented in figures 32 through 43, appendix H. Hover control power is summarized in table 3 and compared with the requirements of MIL-H-8501A (ref 11, app A).

28. Lateral controllability characteristics are summarized in figure 32, appendix H. Comparison of these data with that obtained during the evaluation of the Model 801 tail rotor (ref 2, app A) indicates essentially no change in lateral controllability as a result of the Model 212 tail rotor modification.

Table 3. Hover Control Power.[1]

| Axis | Direction | Control Power[2] (deg) | | |
|---|---|---|---|---|
| | | Test Results | MIL-H-8501A Minimum | MIL-H-8501A IFR Minimum |
| Roll | Left | 2.3 | 1.2 | 1.5 |
| | Right | 2.6 | 1.2 | 1.5 |
| Yaw | Left | 13.2 | 5.0 | 5.0 |
| | Right | 13.5 | 5.0 | 5.0 |

[1]Gross weight: 8700 pounds.
Center-of-gravity location: 199.5 inches.
Density altitude: 1720 feet.
Outside air temperature: 25°C.
Rotor speed: 324 rpm.
Configuration: Hog.
[2]Displacement measured at 1/2 second for roll and 1 second for yaw.

29. Directional controllability characteristics are summarized in figure 38, appendix H. Directional control response and sensitivity at a hover with SCAS ON was essentially the same as the Model 801 tail rotor. With SCAS OFF, left directional control response and sensitivity in a hover was approximately 30 percent higher with the Model 212 tail rotor. In forward flight, with SCAS ON and OFF, left directional control response and sensitivity were approximately 30 percent higher with the Model 212 tail rotor and essentially linear with respect to the magnitude of pedal application. Directional controllability tests indicate essentially no change in aircraft response or sensitivity with right pedal application.

## Arrestment of Hover Turn Rates

30. Hover turn arrestments were executed IGE at approximately 10 feet skid height to determine peak tail rotor power and any associated operational limitations due to tail rotor power train limits. Tests were performed in the Hog configuration at 9000 pounds and 2000 feet density altitude and 8000 pounds at 11,000 feet density altitude. Arrestments were performed by establishing a steady hovering turn at the desired rate, then rapidly applying directional control to stop the turn. As much as full left pedal was used to arrest right hovering turns.

31. Hover turn arrestment data are summarized in figure 44, appendix H. Time histories of hover turn arrestments from a 30-deg/sec right turn at low and high elevations are presented in figures 45 and 46. The peak tail rotor power recorded for the low-density altitude was 220 shp, during which the power was in excess of the 165-shp continuous power limit for 0.6 second. This compares with 225 peak shp and 2.9 seconds for similar conditions with the Model 801 tail rotor (ref 2, app A). At the high test elevation, peak horsepower was 165 shp and the 30-deg/sec turn was arrested in 1.2 seconds from control input. The Model 212 tail rotor provided a more rapid arrestment of the hover turn with lower tail rotor drive train power demands than the Model 801 tail rotor.

32. The current operational turn rate limit is 30 deg/sec. During this evaluation, an arrestment from a 35-deg/sec turn rate was executed at approximately 2000 feet density altitude. This was performed with rapid full left pedal application (approximately 1.2 inches in 0.1 second). Peak tail rotor power was 248 shp and the turn was arrested in 0.7 seconds. The 42-degree gear box exhibited an unusual wear pattern and was changed. Model 212 test results indicate that abrupt arrestment of hover turn rates greater than 30 deg/sec produces excessive loads in the tail rotor drive system. This was also noted during the Model 801 evaluation (ref 2, app A). Large rapid pedal inputs to the left control limit should be avoided to prevent excessive power loading of the AH-1G tail rotor drive train. The operator's manual should be amended to include the following:

**CAUTION**

> Abrupt full left tail rotor control pedal application should be avoided. Abrupt control motion may cause tail rotor overtorque and damage to tail rotor drive train components.

## Translational Flight

33. Translational flight tests were conducted to determine trim requirements and control margins which would be experienced while hovering in winds. Tests were performed at a skid height of approximately 10 feet with flight paths at 45-degree aircraft azimuth increments with SCAS ON in the Hog configuration, at density altitudes of 2000, 5000, and 11,000 feet at 8000 and 9000 pounds. The safety-of-flight release (ref 8, app A) authorized testing to 40 knots true airspeed (KTAS) in sideward flight (90-degree and 270-degree azimuths) which is beyond the planned operational flight envelope of 30 KTAS. A pace vehicle was used to establish ground speed. Translational flight test results are presented in figures 47 through 73, appendix H.

34. The critical wind azimuth for the Model 212 tail rotor configuration is a right crosswind, essentially the same as for the Model 801 tail rotor. The Model 801 tail rotor directional control summary (fig. 20, ref 2, app A) indicates that at a referred gross weight of 11,230 pounds, hovering flight could not be achieved with 10 percent directional control margin remaining. An aiding left crosswind of 8 KTAS was required before adequate directional control margin

could be achieved in a hover. The Model 212 tail rotor configuration at a referred gross weight of 11,270 pounds was capable of approximately 3 KTAS right sideward flight with 10 percent control margin and was flown to 15 KTAS without loss of directional control. At a referred gross weight of 9760 pounds, right sideward flight was performed up to 43 KTAS without loss of directional control; however, this was near the left pedal control limit and is not recommended as an operational capability. As indicated in figure C, comparison of the two tail rotors illustrates that the requirement for a large change in pedal position with airspeed with the AH-1G/801 tail rotor may not provide sufficient gust control, whereas the small change in pedal position with the AH-1G/212 tail rotor will allow more control available (or less control required) to counteract airspeed gusts. The Model 212 tail rotor affords a significant improvement in directional control during right sideward flight at high gross weights and density altitudes. Further testing should be conducted to determine the effects of increased blade angle settings beyond the current 17.7-degree limit.

| MODEL | AVG GROSS WEIGHT (LB) | AVG DENSITY ALTITUDE (FT) | AVG CG LOCATION (IN.) | AVG ROTOR SPEED (RPM) | AVG $C_T$ | AVG $W/\sigma$ |
|---|---|---|---|---|---|---|
| 801 | 8410 | 4680 | 192.3 | 324 | .004800 | 9670 |
| 212 | 8340 | 5380 | 194.9 | 325 | .004832 | 9790 |

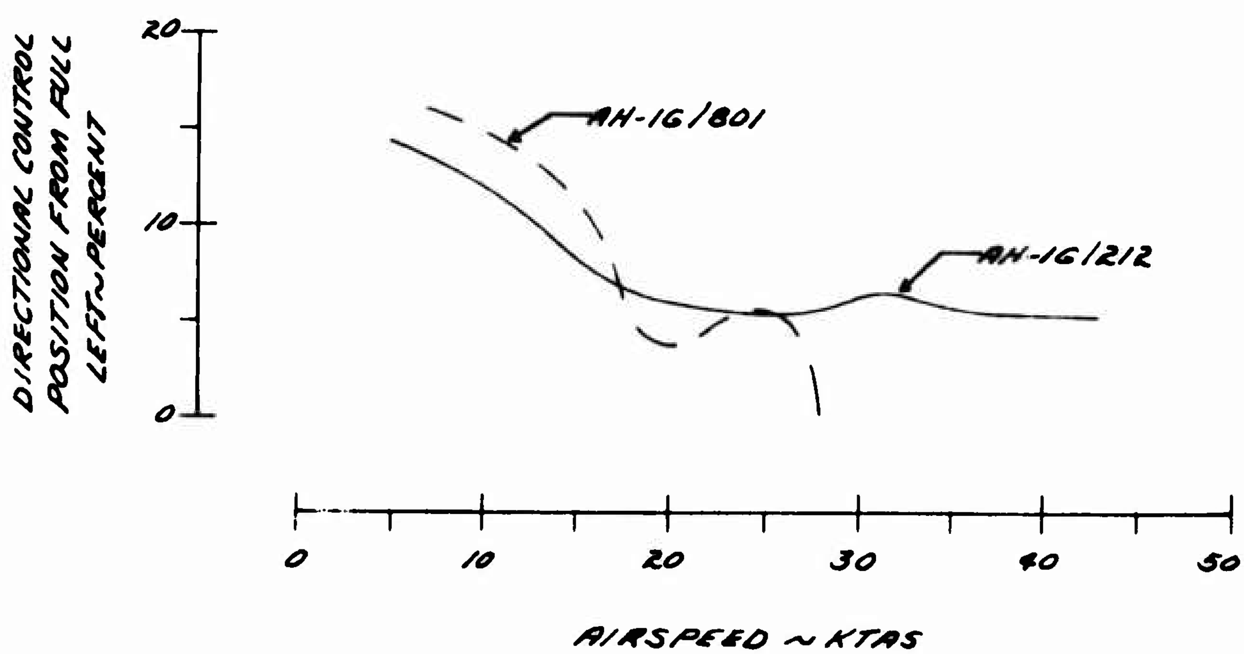



Figure C. Tail Rotor Comparison in Right Sideward Flight.

35. A directional control position margin of 10 percent was discussed in the AH-1G Phase D report (ref 1, app A) and the tractor tail rotor evaluation report (ref 2) as providing minimum adequate directional control margin. The Model 212 tail rotor configured AH-1G was qualitatively evaluated as having adequate directional control margin with 7 percent remaining directional control. This reduced control margin requirement results from the more precise directional control available and the smaller yaw excursions with the Model 212 tail rotor, especially near the control limits. On several occasions, right sideward flight could be made at airspeeds where full left pedal application was required. At similar flight conditions with the Model 801 tail rotor, considerable pilot effort was required to maintain directional control. These factors represent significant improvement in sideward flight handling qualities with the Model 212 installation.

__Autorotational Entry Characteristics__

36. Autorotational entry characteristics (throttle chops) were evaluated to determine aircraft response following sudden engine failure. Engine failure was simulated by rapidly closing the twist grip throttle to the flight-idle position while stabilized at 8500 pounds gross weight, 5000 feet density altitude, aft cg, and airspeeds from 75 KCAS to $V_H$. Following the simulated engine failure, the flight controls (including collective pitch) were held fixed for 2 seconds or until recovery was necessary. Aircraft reaction with SCAS ON and OFF was recorded during the simulated failure and recovery. Results are summarized in figure 74, appendix H. Time histories are presented in figures 75 and 76.

37. The AH-1G with Model 212 tail rotor generally exhibited significantly less severe response following a throttle chop (SCAS ON) than was reported in the Phase D testing (ref 1, app A) of the AH-1G, as is shown in table 4. Delay times prior to recovery were the same for both the standard AH-1G and the AH-1G/212 and failed to meet the military specification (ref 11) minimum of 2 seconds delay time until recovery at high power settings. Maximum yaw rates were 10 to 11 deg/sec for the AH-1G/212, as compared to 12.5 to 14.0 deg/sec with the standard AH-1G at the same airspeed. Aircraft pitch rates were negligible during the simulated failure and recovery.

38. The AH-1G/212 response to simulated sudden engine failure with SCAS OFF was considerably more severe in the roll axis than with SCAS ON. The time histories show roll acceleration approximately three times higher with SCAS OFF and delay time reduced by 0.6 second. The AH-1G autorotational entry characteristics report (ref 12, app A) recommends limiting airspeed to less than 100 KCAS when the SCAS is inoperative. Test data support this recommendation for the 212 tail rotor modified AH-1G. The AH-1G/212 was qualitatively evaluated as being slightly less severe in response to simulated engine failure than the Model 801.

Table 4. Autorotational Roll Response Characteristics.[1]

| Calibrated Airspeed (kt) | Maximum Roll Acceleration ($deg/sec^2$) | | Maximum Roll Rate (deg/sec) | |
|---|---|---|---|---|
| | AH-1G[2] | AH-1G/212[3] | AH-1G[2] | AH-1G/212[3] |
| 114 | 16.0 | 13.5 | 25.5 | 14.0 |
| 126 | 22.0 | 13.0 | 34.0 | 17.0 |
| 133 | 26.5 | 19.5 | 37.5 | 24.0 |

[1]SCAS ON.
Center-of-gravity location: aft.
Density altitude: 5000 feet.
Rotor speed: 324 rpm.
Configuration: Hog.
[2]Gross weight: 9500 pounds.
[3]Gross weight: 8530 pounds.

# CONCLUSIONS

## GENERAL

39. The following conclusions were reached upon completion of testing:

a. Hover performance of the AH-1G helicopter was slightly improved with the Model 212 tail rotor installation (paras 11, 12, and 13).

b. The Model 212 tail rotor provided a more rapid arrestment of hover turns with lower tail rotor drive train power than the Model 801 tractor tail rotor (para 31).

c. Abrupt arrestment of hover turn rates greater than 30 deg/sec produces excessive loading of the tail rotor drive system (para 32).

d. The Model 212 tail rotor affords a significant improvement in directional control during right sideward flight at high gross weights and density altitudes (para 34).

e. The level flight performance, control system characteristics, static longitudinal stability, static lateral and directional stability, dynamic lateral and directional stability below 120 KCAS, lateral controllability, right directional controllability, and critical azimuth characteristics of the Model 212 tail rotor configured AH-1G helicopter are essentially the same as the Model 801 tail rotor (paras 14, 16, 21, 23, 25, 28, and 34).

## SHORTCOMINGS

40. The lateral-directional gust response at airspeeds above 120 KCAS (para 25).

## SPECIFICATION CONFORMANCE

41. Within the scope of this test, the AH-1G helicopter with the Model 212 tail rotor installed failed to meet the following requirements of MIL-H-8501A:

a. Paragraph 3.3.11 - Directional control force of 34 pounds exceeded the 15-pound limit (table 1).

b. Paragraph 3.5.5 - A 2-second collective control delay could not be achieved at high power settings in forward flight following a simulated power failure (para 37).

# RECOMMENDATIONS

42. The shortcoming should be corrected (para 25).

43. The operator's manual should include the following caution:

**CAUTION**

Abrupt full left tail rotor control pedal application should be avoided. Abrupt control motion may cause tail rotor overtorque and damage to tail rotor drive train components.

44. Further testing should be conducted to determine:

a. Airspeed and power combination which produce acceptable short-term lateral-directional handling qualities during flight in turbulence (para 25).

b. Performance and handling qualities with tail rotor blade angle settings beyond the current 17.7-degree limit (para 34).

# APPENDIX A. REFERENCES


1. Final Report, USAAVNTA, Project No. 66-06, *Engineering Flight Test of the AH-1G Helicopter, Phase D, Part 1*, December 1970.

2. Final Report, USAASTA, Project No. 68-37, *Army Preliminary Evaluation of the AH-1G Tractor Tail Rotor Modification*, June 1969.

3. Final Report, USAASTA, Project No. 72-30, "Engineering Flight Test of the AH-1G Helicopter with Model 212 Tail Rotor, Part I, Load Survey," June 1973. Under preparation.

4. Message, AVSCOM, AMSAV-EFT, 7-15, 31 July 1973, unclas, subject: TOW Cobra and AH-1G 212 Tail Rotor Test Changes.

5. Engineering Change Proposal AH-1G 350, Bell Helicopter Company, "Improved Anti-Torque System for the AH-1G Helicopter," 29 August 1967.

6. Technical Manual, TM 55-1520-221-10, *Operator's Manual, Army Model AH-1G Helicopter*, 19 June 1971, with changes 1 through 6.

7. Message, AVSCOM, AMSAV-EFT, 4-10, 13 April 1973, unclas, subject: Safety-of-Flight Release for Conduct of AH-1G/212 Tail Rotor Evaluation.

8. Message, AVSCOM, AMSAV-EFT, 5-06, 4 May 1973, unclas, subject: Safety-of-Flight Release for Conduct of AH-1G/212 Tail Rotor Evaluation.

9. Flight Test Manual, Naval Air Test Center, FTM No. 101, *Helicopter Stability and Control*, 10 June 1968.

10. Engineering Handbook, Army Material Command, AMCP 706-204, "Helicopter Performance Testing." Under preparation.

11. Military Specification, MIL-H-8501A. *Helicopter Flying and Ground Handling Qualities; General Requirements For*, 7 September 1961, with Amendment 1, 3 April 1962.

12. Final Report, USAASTA, Project No. 70-25, *Engineering Flight Test, AH-1G (Huey cobra) Helicopter Autorotational Entry Characteristics*, April 1971.

13. Technical Report, Aeronautical Systems Division, Air Force Systems Command, No. ASNF TN 68-3, *A Graphical Summary of Military Helicopter Flying and Ground Handling Qualities of MIL-H-8501A*, 15 September 1968.

# APPENDIX B. TEST DIRECTIVE

**DEPARTMENT OF THE ARMY**
**HEADQUARTERS, US ARMY AVIATION SYSTEMS COMMAND**
**PO BOX 209, ST. LOUIS, MO 63166**

25 JUL 1972

AMSAV-EFT

SUBJECT: AH-1G/212 Tail Rotor Evaluation

Commanding Officer
US Army Aviation Systems
Test Activity
ATTN: SAVTE-P

This letter transmits AVSCOM Test Directive No. 72-30, subject as above.

FOR THE COMMANDER:

1 Incl
as

ROBERT D. HUBBARD
Acting Chief, Flt Stds & Qual Div
Directorate for RD&E

AVSCOM Test Directive
No. 72-30
AH-1G/212 Tail Rotor Evaluation

1. Purpose.

This test directive tasks ASTA to conduct a flight test evaluation of the Tractor 212 Flex Beam Tail Rotor on the AH-1G Helicopter.

2. Background.

Bell Helicopter recently completed a preliminary load level survey of their Model 212 Tractor Tail Rotor Configuration on the AH-1G Helicopter and the Cobra Product Manager has subsequently requested an Army Flight Test Evaluation be conducted. Indications are that this tail rotor test may be a prelude to a full blown AH-1G IFR evaluation.

3. Test Objective.

To obtain quantitative and qualitative stability and control flight test data on the AH-1G/212 Tractor Tail Rotor Configuration.

4. Special Instructions.

a. Handling qualities are to be evaluated against the MIL-H-8501A IFR handling qualities requirements.

b. The Model 212 flex beam tractor tail rotor will be provided and installed by BHC personnel.

c. Instrumentation of the AH-1G should be initiated at the earliest practical date and will be extensive enough to conduct a follow-on IFR evaluation.

5. Test Schedule.

Tentative schedule is for BHC to initiate tail rotor installation at ASTA the latter part of August 1972 with ASTA flight testing to commence immediately thereafter.

6. Description.

A technical description of the 212 flex beam tractor tail rotor will be provided by on-site BHC personnel.

7. Points of Contact.

AMCPM-CO . . . Mr. C. Gaiser, autovon 698-3304
. . . CWO Gay, autovon 698-3304

AMSAV-EF . . . Mr. J. Dettmer, autovon 698-5446

BHC . . . Mr. G. Nanchy, commercial (817) 280-3231

8. Funding.

The Cobra Product Manager is responsible for reimbursable expense requirements associated with this project and will provide $6000 to ASTA based on the preliminary estimate.

9. Priority.

AVSCOM Priority Number 8 is assigned.

10. Reports.

Seven copies of an ASTA report in letter format is required to be submitted to AMSAV-EF not later than 45 calendar days after test completion.

11. Security Classification.

Unclassified.

12. Equipment.

The tail rotor will be provided by BHC. All other test and test support is the responsibility of ASTA.

13. Safety of Flight Release.

A safety of flight release will be issued to ASTA by the Flight Standards & Qualification Division prior to initiation of flight testing.

# APPENDIX C. TAIL ROTOR DESCRIPTION

## TRACTOR TAIL ROTOR (MODEL 801)

1. The tractor tail rotor (Model 801) is a two-bladed, delta-three hinge type employing preconing. The blade and yoke assembly is mounted to the tail rotor shaft by means of a delta-hinge trunnion. Blade pitch angle is varied by movement of the tail rotor control pedals. Power to drive the tail rotor is supplied by a takeoff on the lower end of the main transmission.

## TAIL ROTOR (MODEL 212)

2. The Model 212 tail rotor is a two-bladed, delta-three hinge type employing a flex-beam yoke. A double counter-weight arrangement reduces the blade feathering moments at high tail rotor collective pitch settings. Location, power source, and controls are essentially the same as the Model 801 tail rotor.

## ANTITORQUE ROTOR DATA

| | Model 801 | Model 212 |
|---|---|---|
| Number of blades | 2 | 2 |
| Diameter | 8.5 ft | 8.5 ft |
| Blade chord | 8.4 in. (constant) | 11.5 in. (constant) |
| Rotor solidity | 0.105 | 0.1436 |
| Blade airfoil | NACA 0010 modified | NACA 0018 at fuselage station (FS) 12.75, tapering linearly to BHC cambered blade section with thickness ratio 8.27 at FS 51 (No NACA number) |
| Blade twist | Zero deg | Zero deg |

# APPENDIX D. PHOTOGRAPHS

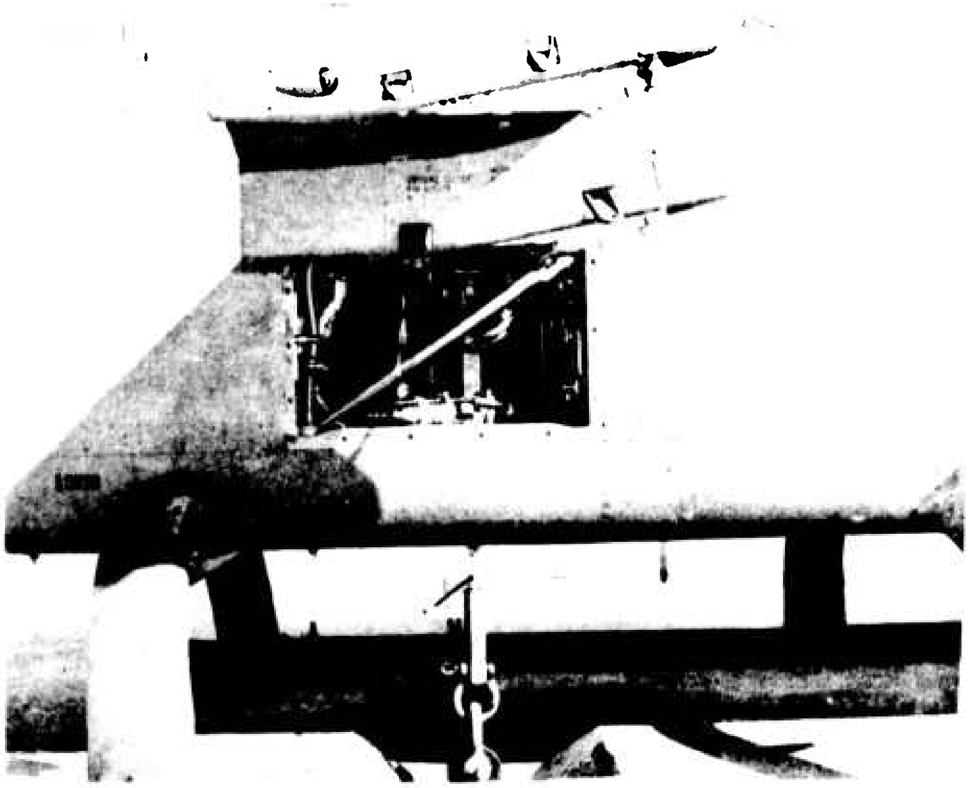


Photo 1. Tie-Down.

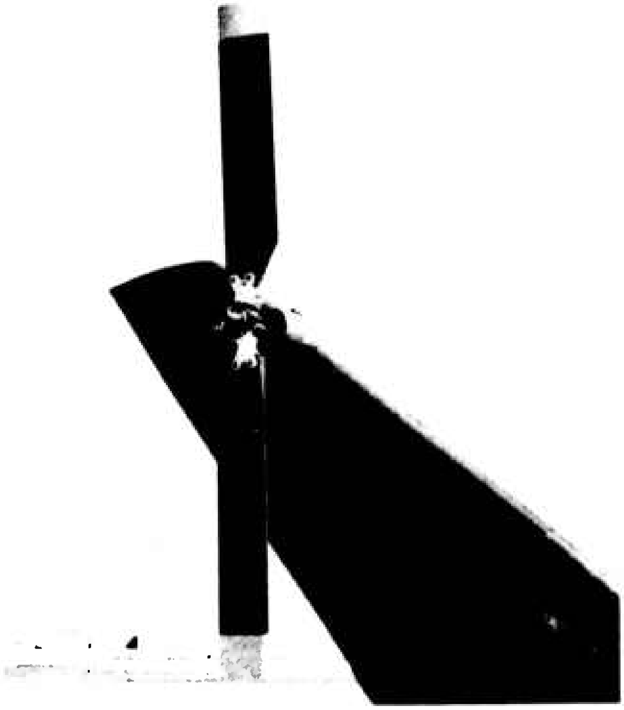


Photo 2. Model 801 Tail Rotor.

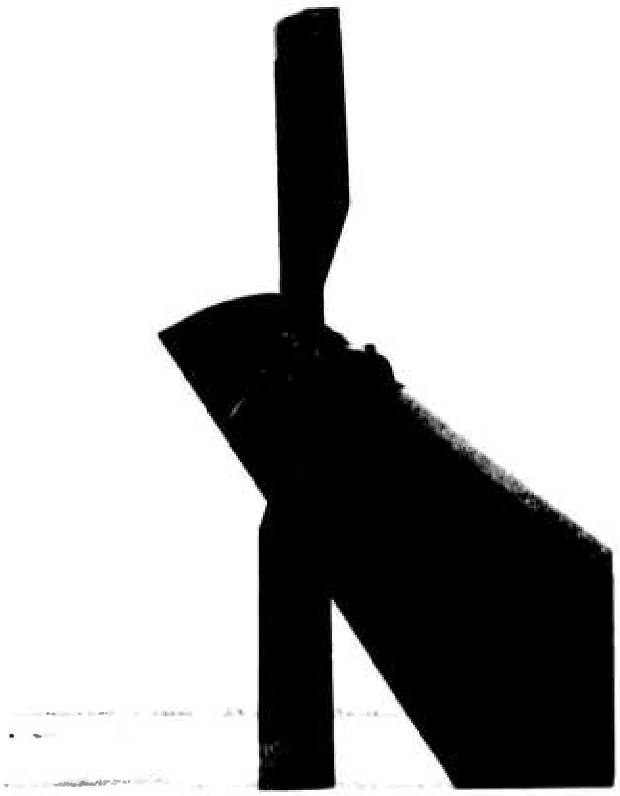


Photo 3. Model 212 Tail Rotor.

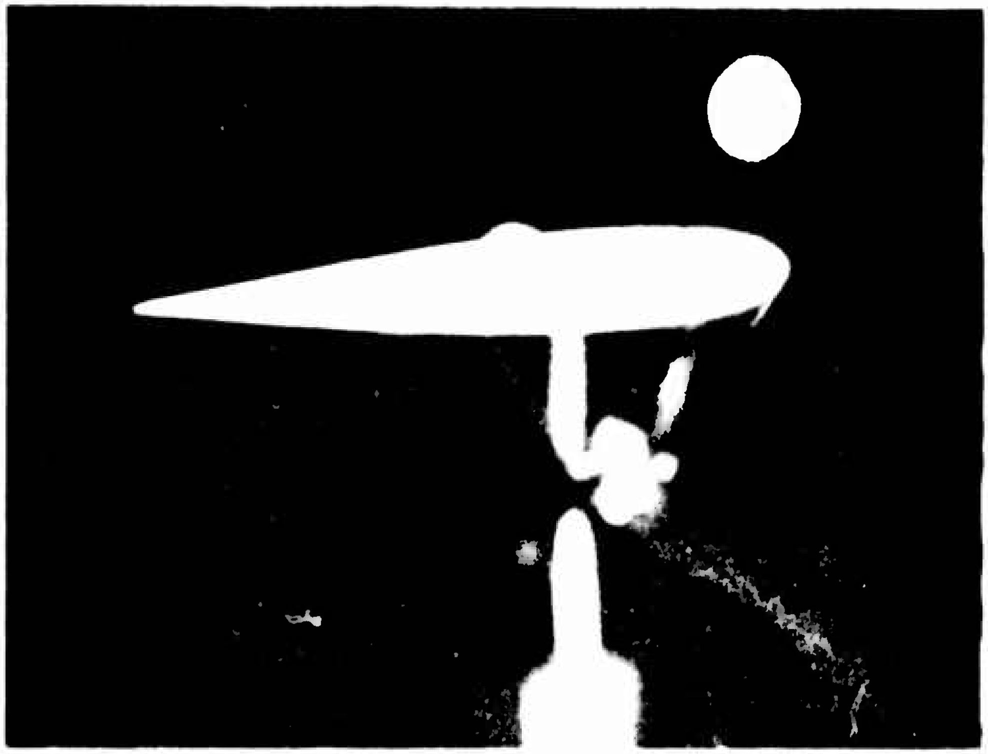


Photo 4. Model 801 Blade Tip.

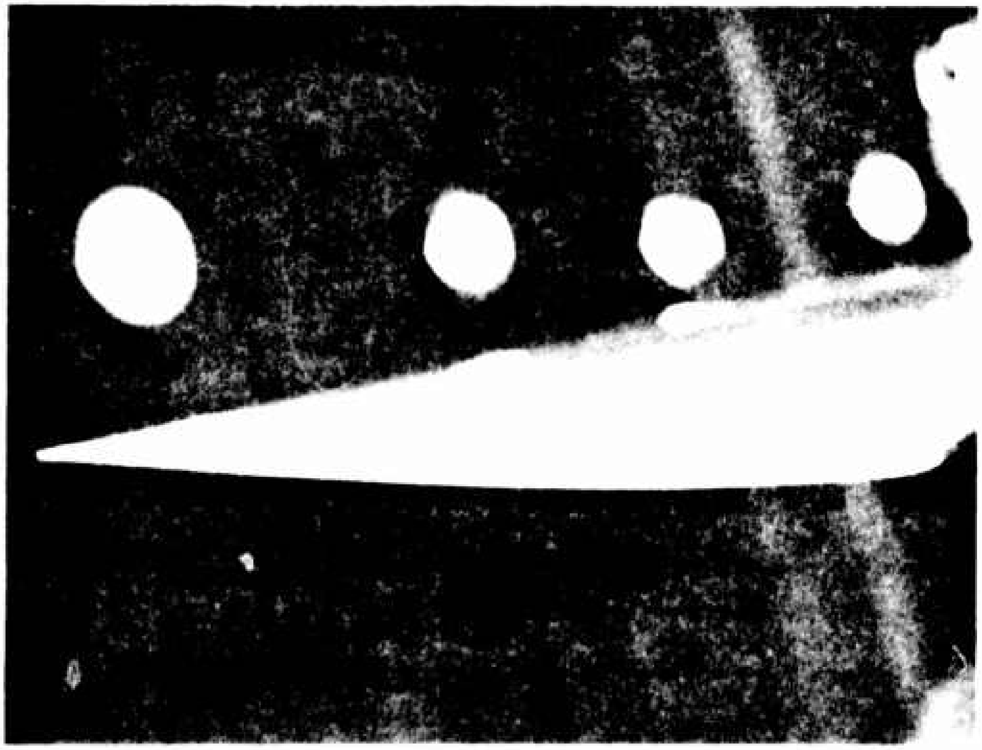


Photo 5. Model 212 Blade Tip.

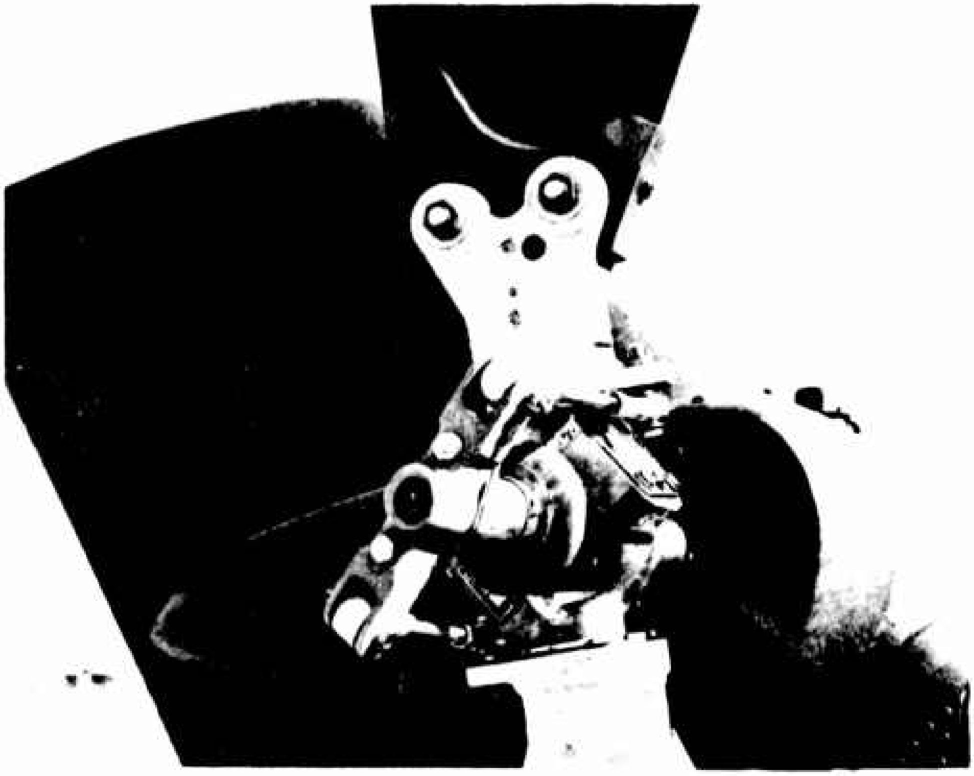


Photo 6. Model 801 Tail Rotor Hub.

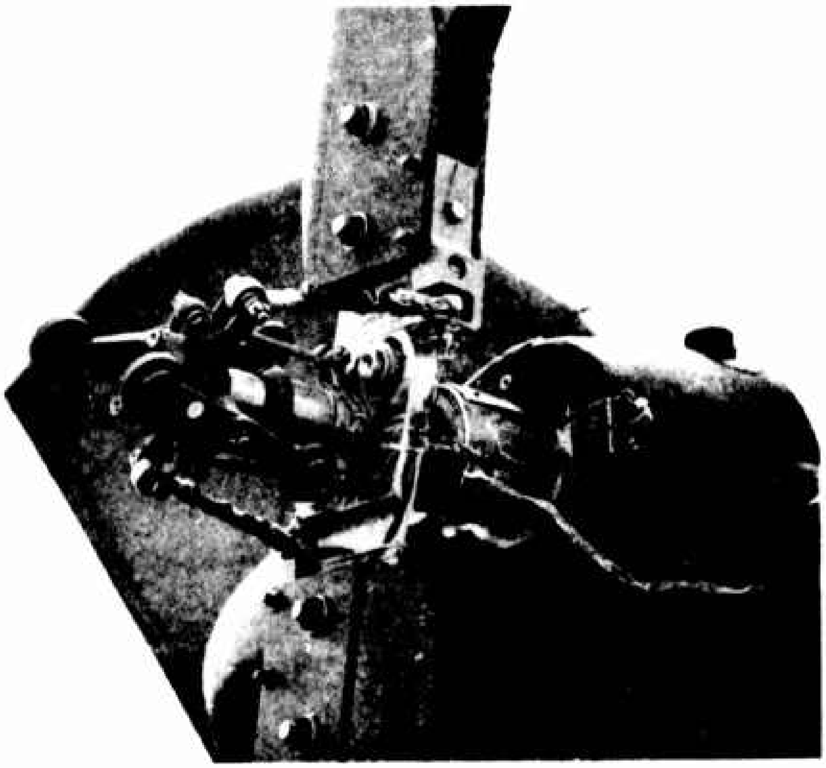
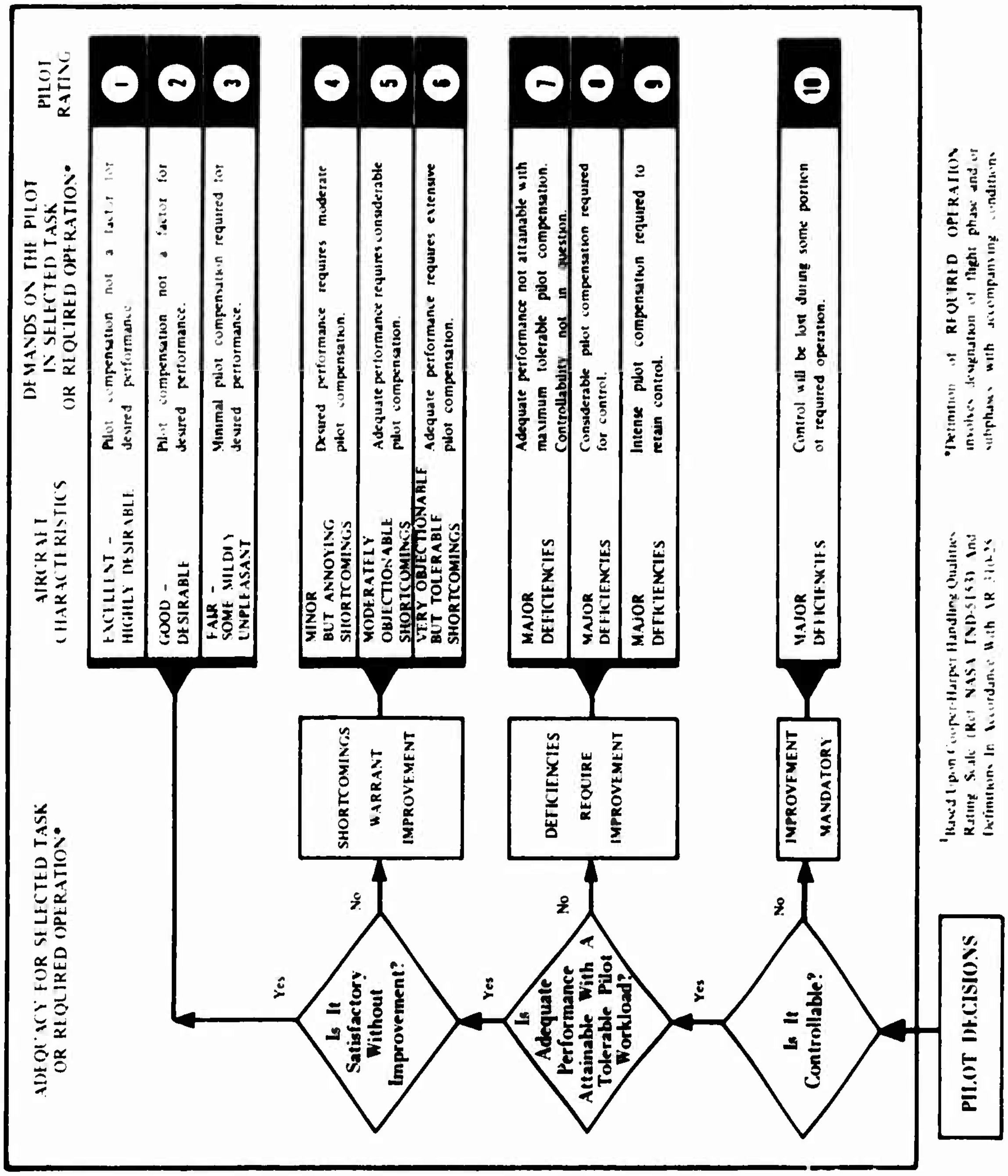


Photo 7. Model 212 Tail Rotor Hub.

# APPENDIX E. HANDLING QUALITIES RATING SCALE




[1]Based Upon Cooper-Harper Handling Qualities Rating Scale (Ref NASA TND-5153) And Definitions In Accordance With AR 310-25

*Definition of REQUIRED OPERATION involves designation of flight phase and/or subphases with accompanying conditions

# APPENDIX F. DATA REDUCTION TECHNIQUES

## INSTRUMENTATION

1. All instrumentation was calibrated prior to commencing the test program. All quantitative data obtained during this flight test program were derived from the special sensitive instrumentation listed in appendix G. Data were obtained from three aircraft sources and two ground sources. The aircraft sources were a magnetic tape, the engineer panel, and the pilot panel. The ground support sources were a ground weather station (used for hover and translational flight tests), and a calibrated pace vehicle (used for translational flight tests).

## WEIGHT AND BALANCE

2. The test aircraft was weighed after the installation of test instrumentation. The fuel load for each test flight was determined prior to engine start and after engine shutdown by measuring the fuel specific gravity and temperature of the fuel, and by using an external calibrated sight gauge connected to the fuel cell to determine total fuel volume. Fuel used in flight was recorded by a calibrated fuel-used system, and the final fuel-used reading following engine shutdown was cross-checked with the sight gauge readings following each flight. Helicopter loading and cg were controlled by ballast installed at various locations in the aircraft.

## AIRSPEED CALIBRATION

3. The calibration of the airspeed system was accomplished by determining the existing airspeed position error of the test nose boom in level, climbing, diving, and autorotational flight. A mathematical curve fit was applied to the data obtained from these tests, and is graphically presented in figure 1, appendix G, depicting calibrated airspeed ($V_{CAL}$) as a function of instrument corrected indicated airspeed ($V_{IC}$). With the following functional relationship a standard estimate of error of 0.91 knot was obtained.

$$V_{CAL} = 12.645 + 0.707\,(V_{IC}) + 3.38 \times 10^{-3}\,(V_{IC})^2 - 1.15 \times 10^{-5}\,(V_{IC})^3 \qquad (1)$$

## NONDIMENSIONAL METHOD

4. The helicopter performance results may be generalized through the use of nondimensional coefficients. The test results obtained at specific test conditions may be used to accurately define performance at conditions not specifically tested. The following nondimensional coefficients were used.

$$\text{Thrust coefficient} = C_T = \frac{\text{Thrust}}{\rho A(\Omega R)^2} = \frac{GW}{\rho A(\Omega R)^2} \qquad (2)$$

$$\text{Power coefficient} = C_P = \frac{(SHP)(550)}{\rho A(\Omega R)^3} \qquad (3)$$

Where: GW = Gross weight (lb)
$\rho$ = Air density (slug/ft$^3$)
A = Main rotor disc area (ft$^2$)
$\Omega$ = Main rotor rotational frequency (rad/sec)
R = Main rotor radius (ft)
SHP = Shaft horsepower

## PERFORMANCE

### Power Determination

5. Horsepower transmitted by a rotating shaft may be expressed as follows.

$$SHP = \frac{2\pi}{(12)(33{,}000)}(N)\ (Q) \qquad (4)$$

Where: N = Output shaft rotational speed (rpm)
Q = Output shaft torque (in.-lb)

6. The calibration of the engine torquemeter system for engine S/N LE 17292 is graphically presented in figure 2, appendix G. The data obtained from this calibration correlated with the specification engine, but were insufficient to cover the entire operating torque range. Therefore, a mathematical curve fit was applied to the data and this curve was used to obtain engine output shaft torque (ESQ) as a function of engine output torque pressure (QE). The following equation was used and yielded a standard estimate of error of 56.9 in-lb.

$$ESQ = 150.178 + 218.458(QE) - 1.34 \times 10^{-2}(QE)^2 \qquad (5)$$

7. Antitorque system output torque was measured at the output shaft of the 90-degree tail rotor gearbox using a strain gage bridge and slip ring assembly. The following calibration equation for converting encoded pulse code modulation (PCM) counts from the magnetic tape system into tail rotor torque (TRQ) was used.

$$TRQ_{(in.-lb)} = -115.572 + 38.556(V) \qquad (6)$$

Where: V = Differential bridge voltage expressed in PCM counts

8. Engine output shaft speed and tail rotor speed were determined from rotor speed as follows.

$$N_E = (N_R)(20.383) \qquad (7)$$

$$N_{TR} = (N_R)(5.10859) \qquad (8)$$

Where: $N_E$ = Engine output shaft rotational speed
$N_R$ = Main rotor rotational speed
$N_{TR}$ = Tail rotor rotational speed

9. Substituting equations 5, 6, 7, and 8 into equation 4 (as appropriate), equations for determining engine output shaft horsepower ($SHP_T$) and tail rotor shaft horsepower ($SHP_{TR}$) may be developed.

$$SHP_T = \left[\frac{2\pi}{(12)(33,000)}\right]\left[150.178 + 218.458(QE) - 1.34 \times 10^{-2}(QE)^2\right]\left[N_E\right]$$

$$SHP_T = (3.234 \times 10^{-4})(ESQ)(N_R) \qquad (9)$$

$$SHP_{TR} = \left[\frac{2\pi}{(12)(33,000)}\right]\left[-115.572 + 38.556(V)\right]\left[N_{TR}\right]$$

$$SHP_{TR} = (8.106 \times 10^{-5})(TRQ)(N_R) \qquad (10)$$

## Antitorque System Performance

10. The performance of the antitorque rotor system in hover and translational flight was defined by tail rotor horsepower, tail rotor thrust, and directional control (pedal) position.

11. Assuming all restoring directional moment to maintain stabilized hover to be generated by the antitorque system, the thrust from the tail rotor in a hover ($thrust_{TR}$) can be determined from the tail fin lateral bending moment (TFLB) and its moment arm of 41 inches by the following equation.

$$\text{Thrust}_{TR} = \frac{TFLB}{41} \tag{11}$$

12. Assuming that in hover the free air temperature of the air mass flow passing through the tail rotor was not influenced by the hot gases emitted from the engine, the nondimensional thrust coefficient of the tail rotor in hover was determined from the definition of equation 2.

$$C_{T_{TR}} = \frac{\text{Thrust}_{TR}}{\rho A_{TR} (\Omega R)^2_{TR}} \tag{12}$$

Where: Subscript TR = Tail rotor

13. The position of the directional control was determined by measuring pedal position. Full left directional control application resulted in an average tail rotor blade angle of 17.7 degrees for the test aircraft. The total directional control (pedal) displacement (full left to full right) resulted in a 28.0-degree change in tail rotor blade angle. Total control position equals pilot control input plus SCAS input.

## Hover Performance

14. Hovering data collected in terms of gross weight, shp required, and ambient air conditions were used to define the relationship between thrust ($C_T$) and power ($C_P$) coefficients as shown in equations 2 and 3, respectively. This relationship is unique for every skid height. Summary hovering performance was calculated from nondimensional hovering curves by dimensionalizing the curves at selected ambient conditions.

15. To establish a trend between the Model 801 and 212 tail rotor configured AH-1G helicopters, with the limited amount of data available from the Model 801 configuration testing, hover data from both were subjected to a least-squares parabolic curve fit. Model 801 configuration hover performance values presented in this report are based upon this curve fit and do not exactly represent the curves depicted in reference 2, appendix A.

## Level Flight Performance

16. Level flight data were obtained by measuring the shaft horsepower required to maintain level flight at various airspeeds. An almost constant $C_T$ was maintained by increasing altitude as fuel was consumed.

17. From the definition of Cp in equation 3, the following relationship can be derived for presentation of test day data at a standard-day average density altitude. Each level flight speed-power point was corrected to standard-day conditions by this method.

$$SHP_S = (SHP_T)\,\frac{\rho_S}{\rho_t} \qquad (13)$$

Where: Subscript S = Standard day
Subscript T = Test day

18. True airspeed ($V_T$) was calculated from calibrated airspeed as follows.

$$V_T = \frac{V_{CAL}}{\sqrt{\sigma}} \qquad (14)$$

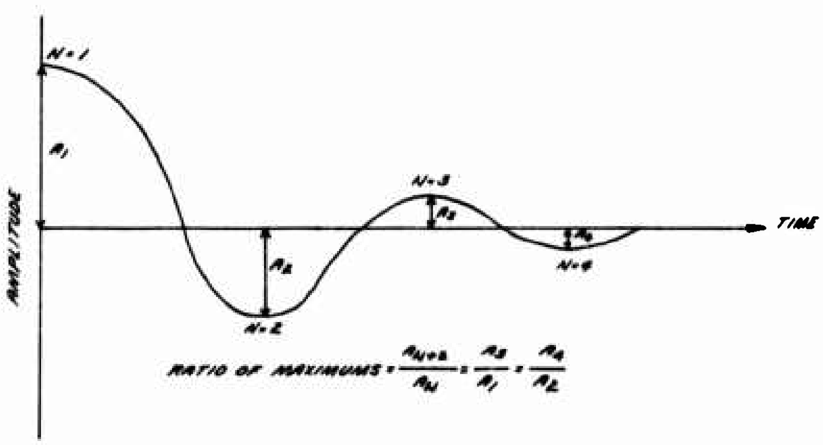
Where: $\sigma$ = Density ratio

## HANDLING QUALITIES

### Stability

19. The damping ratio for an oscillatory aircraft response to a puise input of the flight controls was determined by the ratio of maxim ms method presented in reference 13, appendix A. Briefly, this method involved the determination of the ratio of alternate successive maximum values of the parameter being observed. The ratio of maximums obtained was related to the damping ratio by graphical means given in the previously cited reference. A time history of sideslip angle was used to determine damping ratio for directional pulses and a time history of roll rate was used for lateral pulses.

FIGURE 1



# APPENDIX G. TEST INSTRUMENTATION

1. The test instrumentation was installed, calibrated, and maintained by the Instrumentation and Calibration Division of USAASTA. The tail rotor slip ring assembly, tail rotor blade pitch angle potentiometer, and tail fin lateral bending strain gage were installed and calibrated under contract by Bell Helicopter Company. A test boom with a swiveling pitot-static head was installed at the nose of the aircraft, and was connected to sensitive airspeed and altimeter indicators on both instrument panels and recorded on magnetic tape. All data were obtained from sensitive instrumentation and displayed or recorded on the following aircraft sources.

PILOT PANEL

Airspeed (boom)
Airspeed (ship's system)
Altitude (boom)
Altitude (ship's system)
Rate of climb
Main rotor speed
Angle of sideslip
Center-of-gravity normal acceleration
Engine torque (standard system)

ENGINEER PANEL

Airspeed (boom)
Altitude (boom)
Main rotor speed
Outside air temperature
Fuel used (counter)
Directional control position
Remote time code
Exhaust gas temperature
Gas producer speed ($N_1$)
Engine torque (standard system)
Tail rotor shaft torque
Tether rig cable tension

| MAGNETIC TAPE | ACCURACY ESTIMATE |
|---|---|
| Airspeed (boom) | 1 knot |
| Altitude (boom) | 25 feet |
| Longitudinal control position | 0.1 inch |
| Lateral control position | 0.1 inch |
| Directional control position | 0.1 inch |
| Collective control position | 0.1 inch |
| Throttle position | 0.5 percent |
| Longitudinal control position after SCAS | 0.1 inch |
| Lateral control position after SCAS | 0.1 inch |
| Directional control position after SCAS | 0.1 inch |
| Longitudinal stick force | 0.5 pound |
| Lateral stick force | 0.5 pound |
| Directional pedal force | 0.5 pound |
| Pitch attitude | 0.5 degree |
| Roll attitude | 0.5 degree |
| Yaw attitude | 0.5 degree |
| Pitch rate | 0.5 deg/sec |
| Roll rate | 0.5 deg/sec |
| Yaw rate | 0.5 deg/sec |
| Pitch angular acceleration | 1 deg/sec$^2$ |
| 2Roll angular acceleration | 1 deg/sec$^2$ |
| Yaw angular acceleration | 1 deg/sec$^2$ |
| Angle of attack | 0.5 degree |
| Angle of sideslip | 0.5 degree |
| Center-of-gravity normal acceleration | 0.1g |
| Outside air temperature | 0.5°C |
| Main rotor speed | 1 rev/min |
| Engine delta torque pressure | 0.5 pound/inch$^2$ |
| Tail rotor shaft torque | 5 foot-pounds |
| Tether rig cable tension | 20 pounds |
| Tail fin lateral bending moment (fin station 41) | 50 inch-pounds |
| Tail rotor blade pitch angle | 0.5 degree |
| Time code | |
| Pilot event | |
| Engineer event | |

2. Cyclic and pedal mechanical fixtures were utilized in the forward cockpit to obtain a desired control input size about the lateral and directional axes.

3. The following calibrations graphically depict the equations used for determining engine torque and calibrated airspeed.

## FIGURE 1

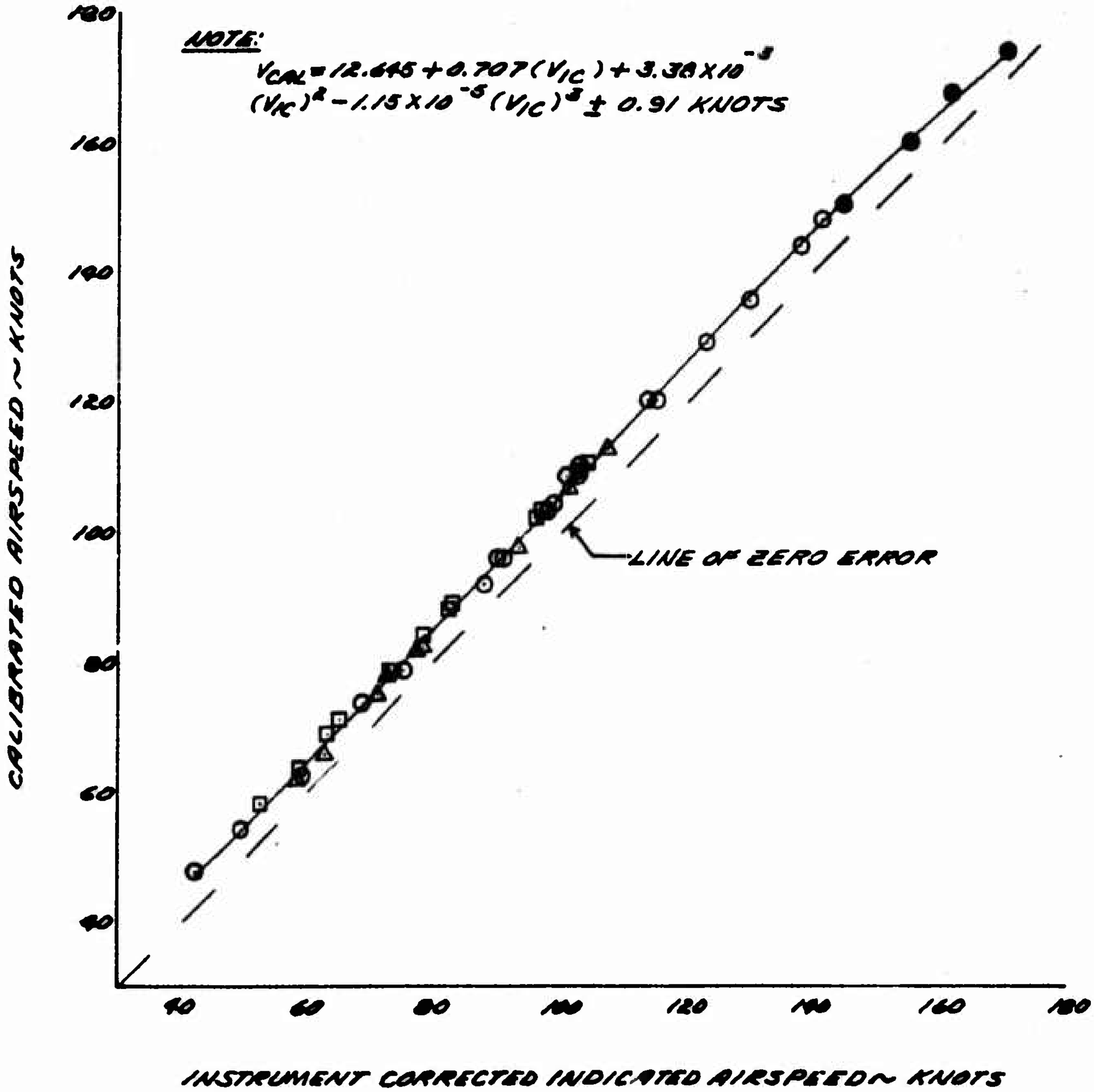
## AIRSPEED CALIBRATION

## AH-1S USA S/N 71-20985

MAIN ROTOR SPEED = 324 RPM

LONGITUDINAL CENTER OF GRAVITY = 192.0 IN.

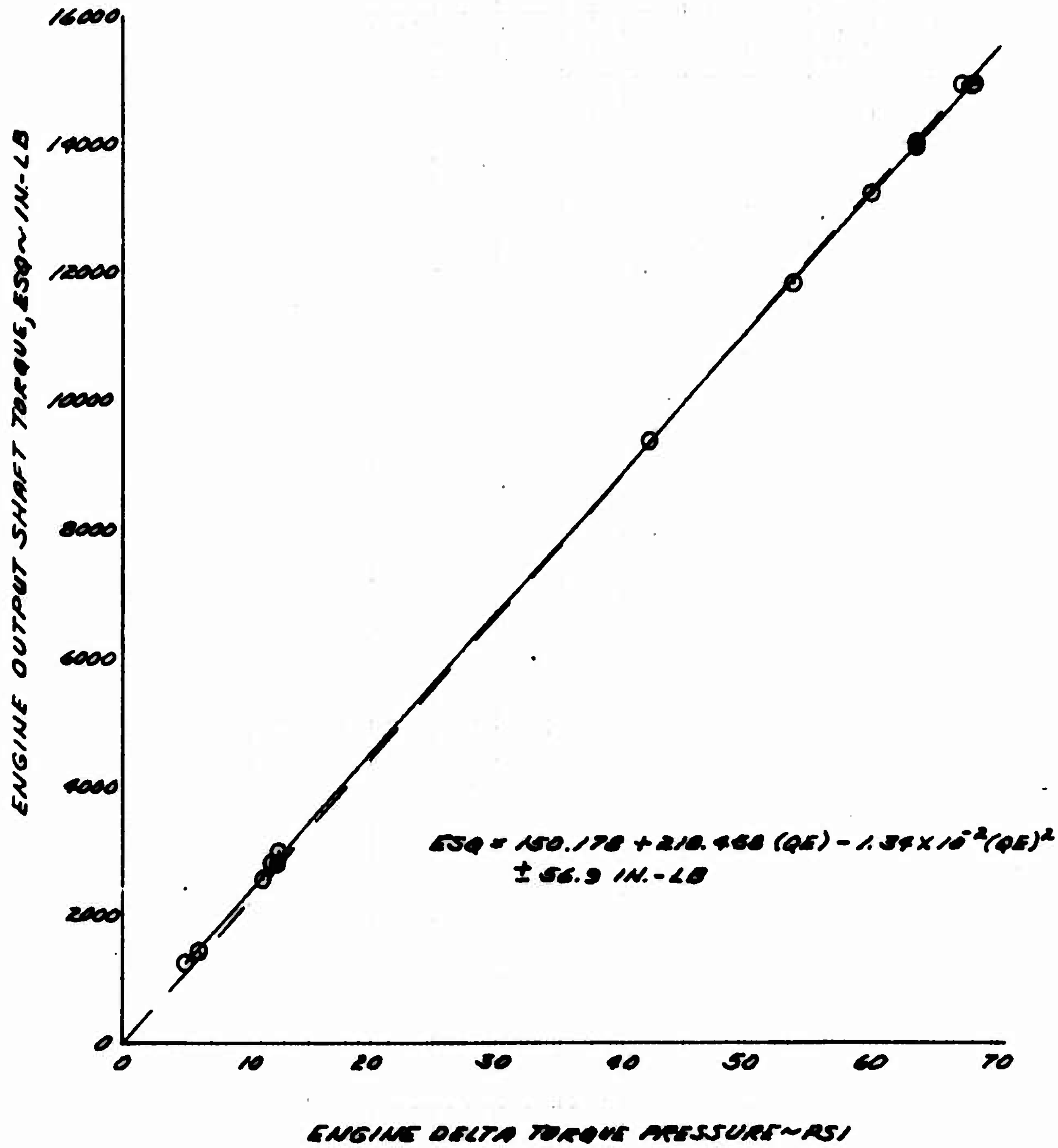
| SYMBOL | FLIGHT CONDITION | AVG DENSITY ALTITUDE (FT) | AVG OAT (°C) |
|---|---|---|---|
| ○ | LEVEL | 4200 | 6.0 |
| □ | CLIMB | 5100 | 5.0 |
| △ | AUTO | 4300 | 6.0 |
| ● | DIVE | 3000 | 8.0 |



## FIGURE 2
## ENGINE CHARACTERISTICS
### T53-L-13 S/N LE 17292

**NOTES:**

1. POINTS OBTAINED FROM ENGINE ACCEPTANCE CALIBRATION TEST CONDUCTED 9 APRIL 1972.
2. SOLID LINE DEPICTS ENGINE S/N LE 17292.
3. BROKEN LINE DEPICTS SPECIFICATION ENGINE SPEC. NO. 104.33, 6 MAY 1966.



# APPENDIX H. AH-1G/212 TEST DATA

## INDEX

FIGURE 1

5 FOOT IGE HOVER CAPABILITY

AH-1G USA S/N 71-20985

MILITARY RATED POWER AVAILABLE

NOTES:

1. SHP OBTAINED FROM FIGURE 7.
2. CURVES DERIVED FROM FIGURE 3.
3. WIND LESS THAN 3 KNOTS.
4. ROTOR SPEED = 324 RPM.
5. VERTICAL HEIGHT FROM BOTTOM OF SKID TO CENTER OF ROTOR HUB = 11.58 FT.
6. BROKEN LINE DEPICTS 10 PERCENT DIRECTIONAL CONTROL MARGIN RESTRICTION.

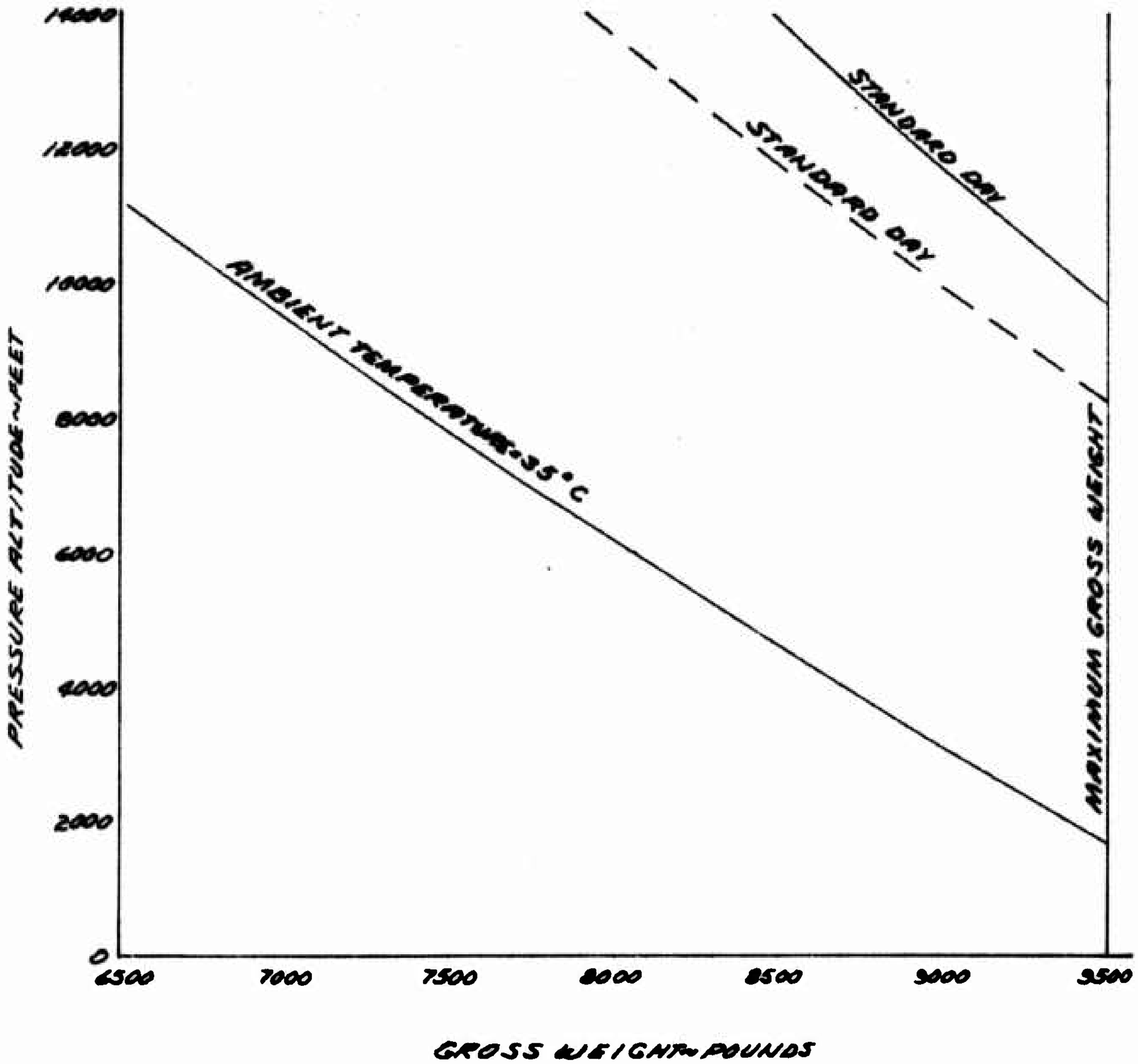


FIGURE 2

OGE HOVER CAPABILITY

AH-1G USA S/N 71-20985

MILITARY RATED POWER AVAILABLE

NOTES:

1. SHP OBTAINED FROM FIGURE 7.
2. CURVES DERIVED FROM FIGURE 4.
3. WIND LESS THAN 3 KNOTS.
4. ROTOR SPEED = 324 RPM.
5. VERTICAL HEIGHT FROM BOTTOM OF SKID TO CENTER OF ROTOR HUB = 11.58 FT.
6. BROKEN LINE DEPICTS 10 PERCENT DIRECTIONAL CONTROL MARGIN RESTRICTION.

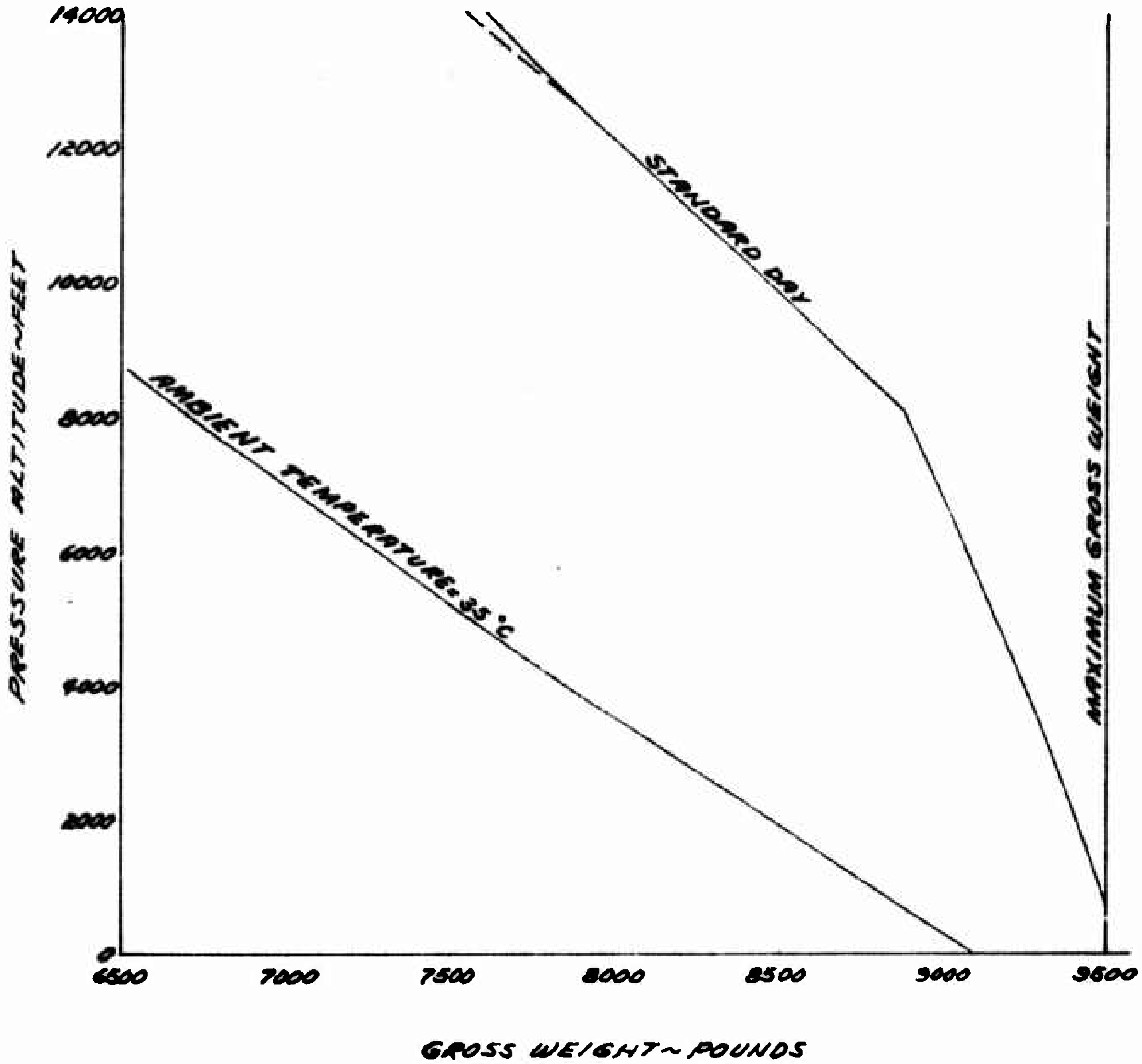


FIGURE 3

NON-DIMENSIONAL HOVERING PERFORMANCE

AH-1G USA S/N 71-20985

IGE SKID HEIGHT = 5 FEET

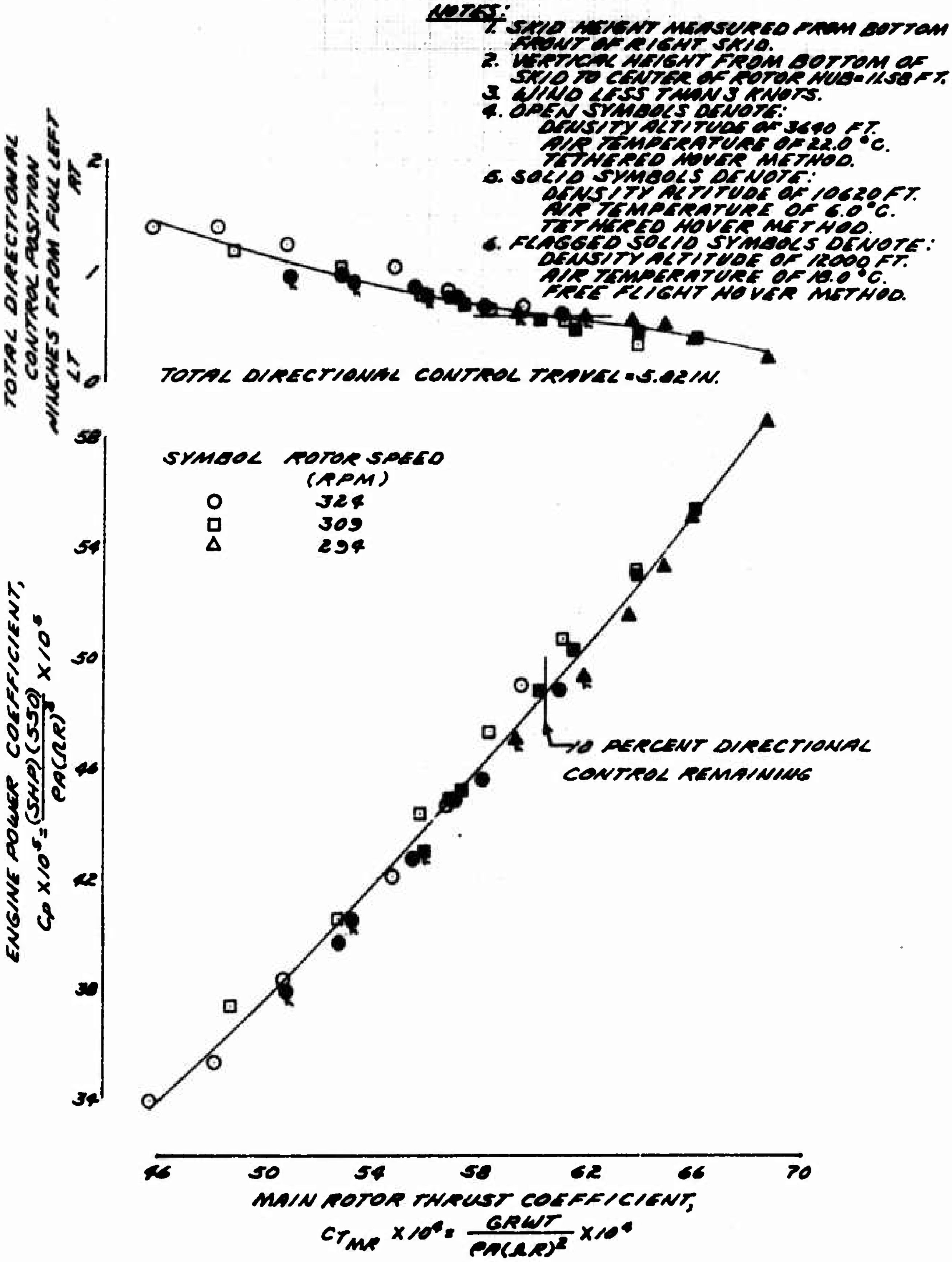


FIGURE 4

NON-DIMENSIONAL HOVERING PERFORMANCE

AH-1G USA S/N 71-20985

OGE SKID HEIGHT = 100 FEET

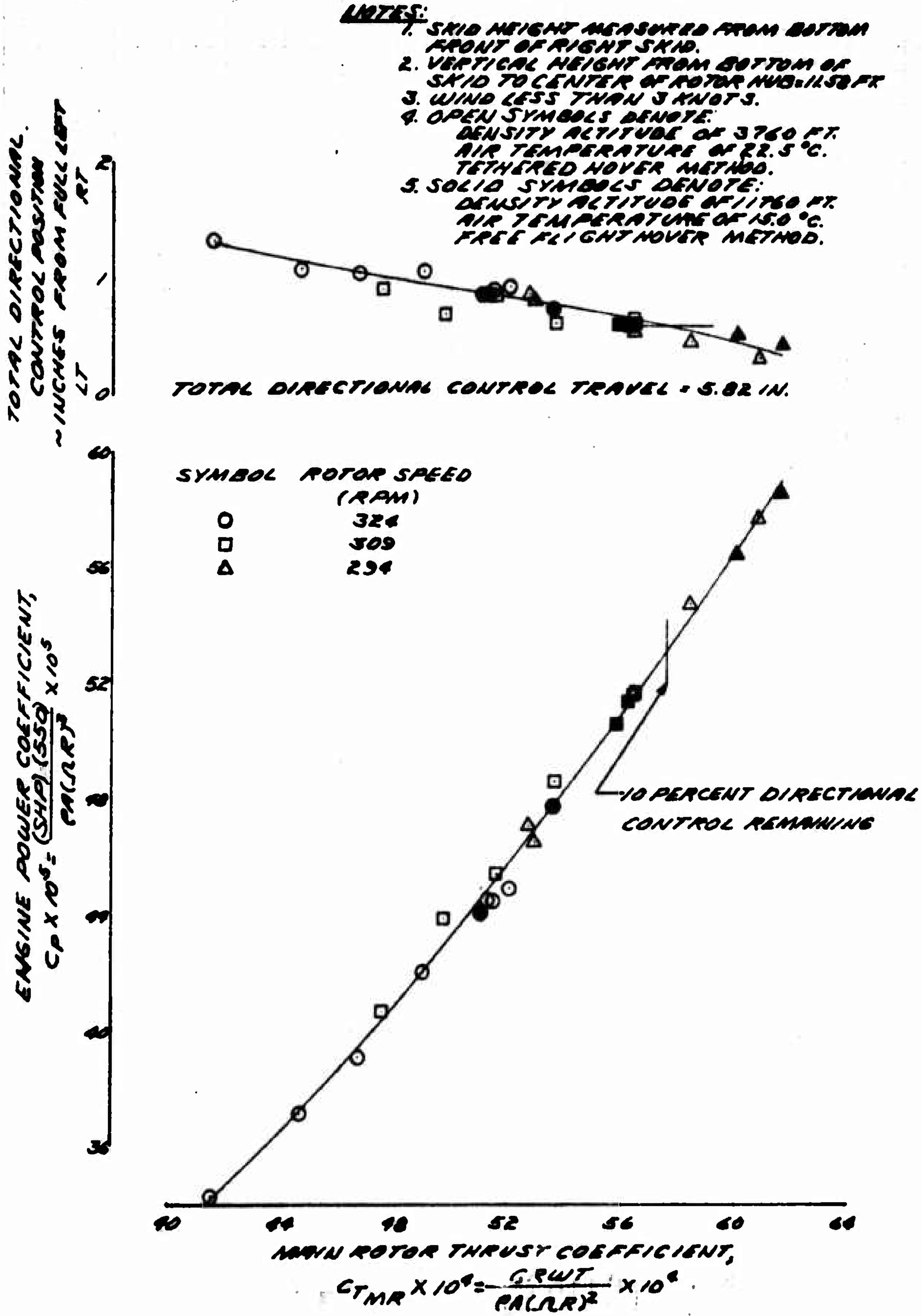


FIGURE 5
NON-DIMENSIONAL TAIL ROTOR PERFORMANCE
AH-1G USA S/N 71-20985
IGE SKID HEIGHT = 5 FEET

NOTES:
1. OPEN SYMBOLS DENOTE:
DENSITY ALTITUDE OF 3640 FT.
AIR TEMPERATURE OF 22.0 °C.
TETHERED HOVER METHOD.
2. SOLID SYMBOLS DENOTE
DENSITY ALTITUDE OF 10620 FT.
AIR TEMPERATURE OF 6.0 °C.
TETHERED HOVER METHOD.
3. FLAGGED SYMBOLS DENOTE:
DENSITY ALTITUDE OF 12000 FT.
AIR TEMPERATURE OF 18.0 °C.
FREE FLIGHT HOVER.
4. $\ell$ (PERPENDICULAR DISTANCE BETWEEN CENTERLINES OF MAIN AND TAIL ROTOR SHAFTS) = 26.73 FT.

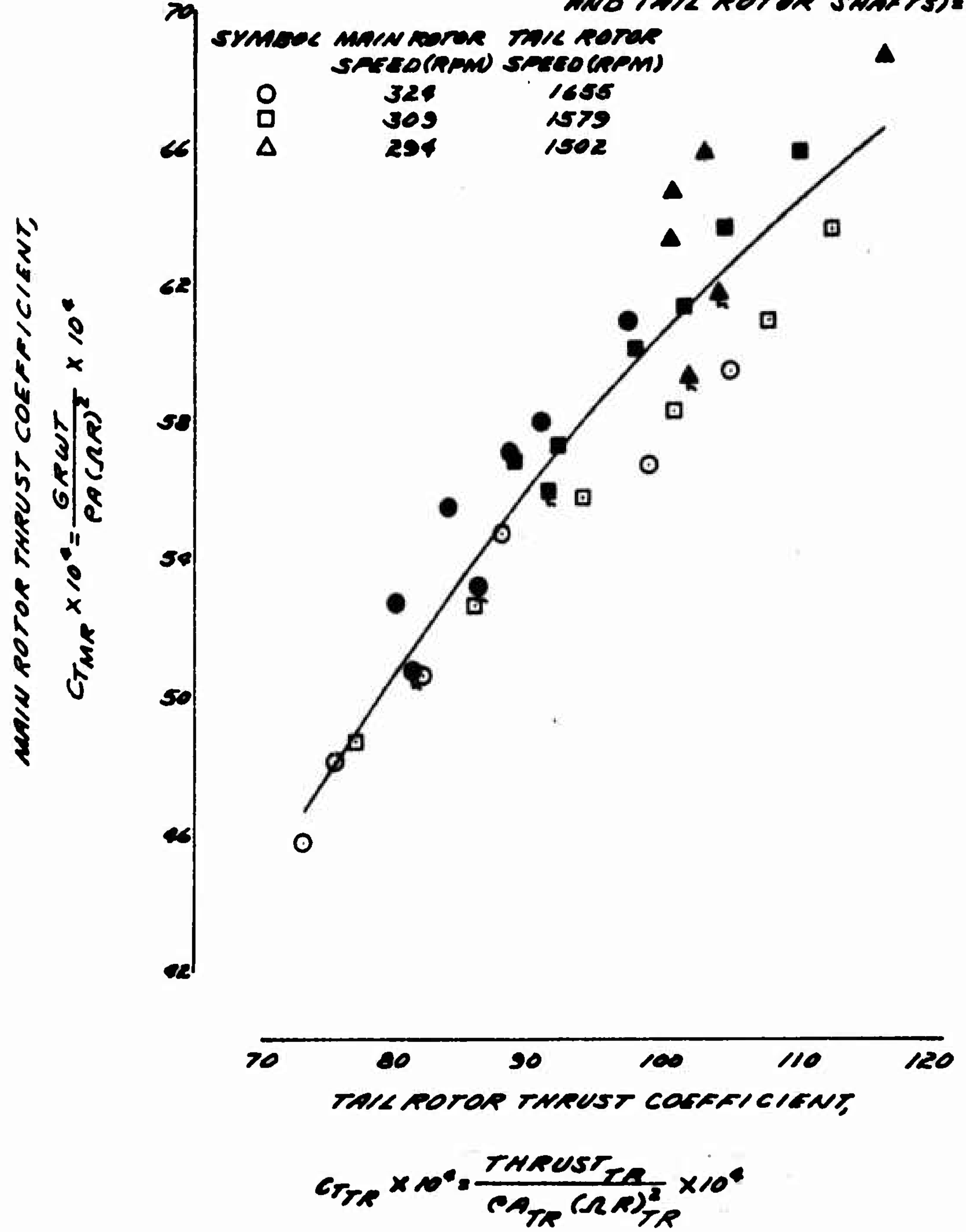


FIGURE 6

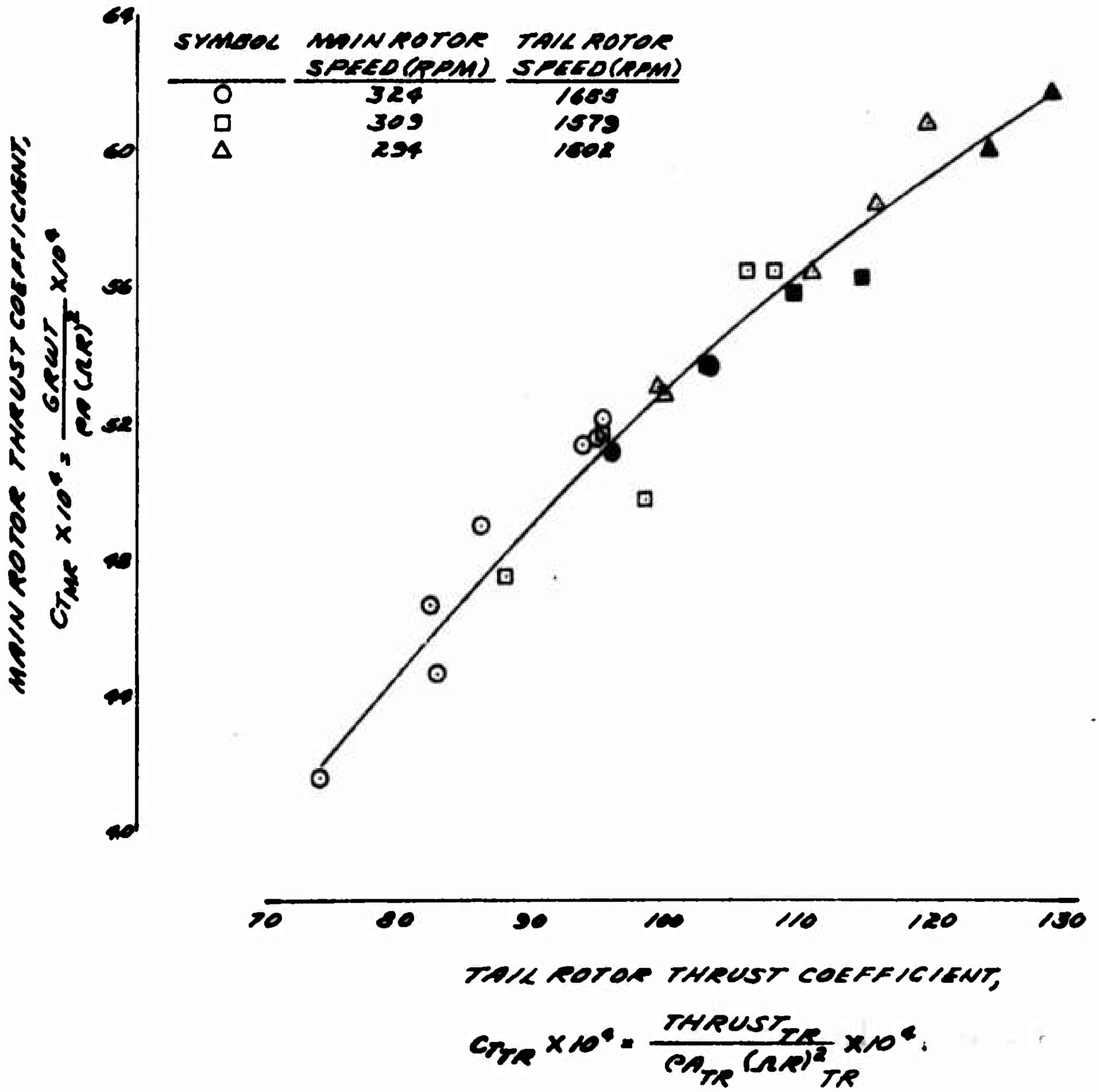
NON-DIMENSIONAL TAIL ROTOR PERFORMANCE

AH-1G USA S/N 71-20986

OGE SKID HEIGHT = 100 FEET

NOTES:

1. OPEN SYMBOLS DENOTE:
   DENSITY ALTITUDE OF 3760 FT.
   AIR TEMPERATURE OF 22.5 °C.
   TETHERED HOVER METHOD.
2. SOLID SYMBOLS DENOTE:
   DENSITY ALTITUDE OF 11760 FT.
   AIR TEMPERATURE OF 15.0 °C.
   FREE FLIGHT HOVER METHOD.
3. $\ell$ (PERPENDICULAR DISTANCE BETWEEN CENTERLINES OF MAIN AND TAIL ROTOR SHAFTS) = 26.73 FT.



## FIGURE 7
## NON-DIMENSIONAL TAIL ROTOR PERFORMANCE
## AH-1G USA S/N 71-20985
## IGE SKID HEIGHT= 5 FEET

NOTES:

1. OPEN SYMBOLS DENOTE:
   DENSITY ALTITUDE OF 3640 FT.
   AIR TEMPERATURE OF 22.0 °C.
   TETHERED HOVER METHOD.
2. SOLID SYMBOLS DENOTE:
   DENSITY ALTITUDE OF 10620 FT.
   AIR TEMPERATURE OF 6.0 °C.
   TETHERED HOVER METHOD.
3. FLAGGED SYMBOLS DENOTE:
   DENSITY ALTITUDE OF 12000 FT.
   AIR TEMPERATURE OF 18.0 °C.
   FREE FLIGHT HOVER METHOD.

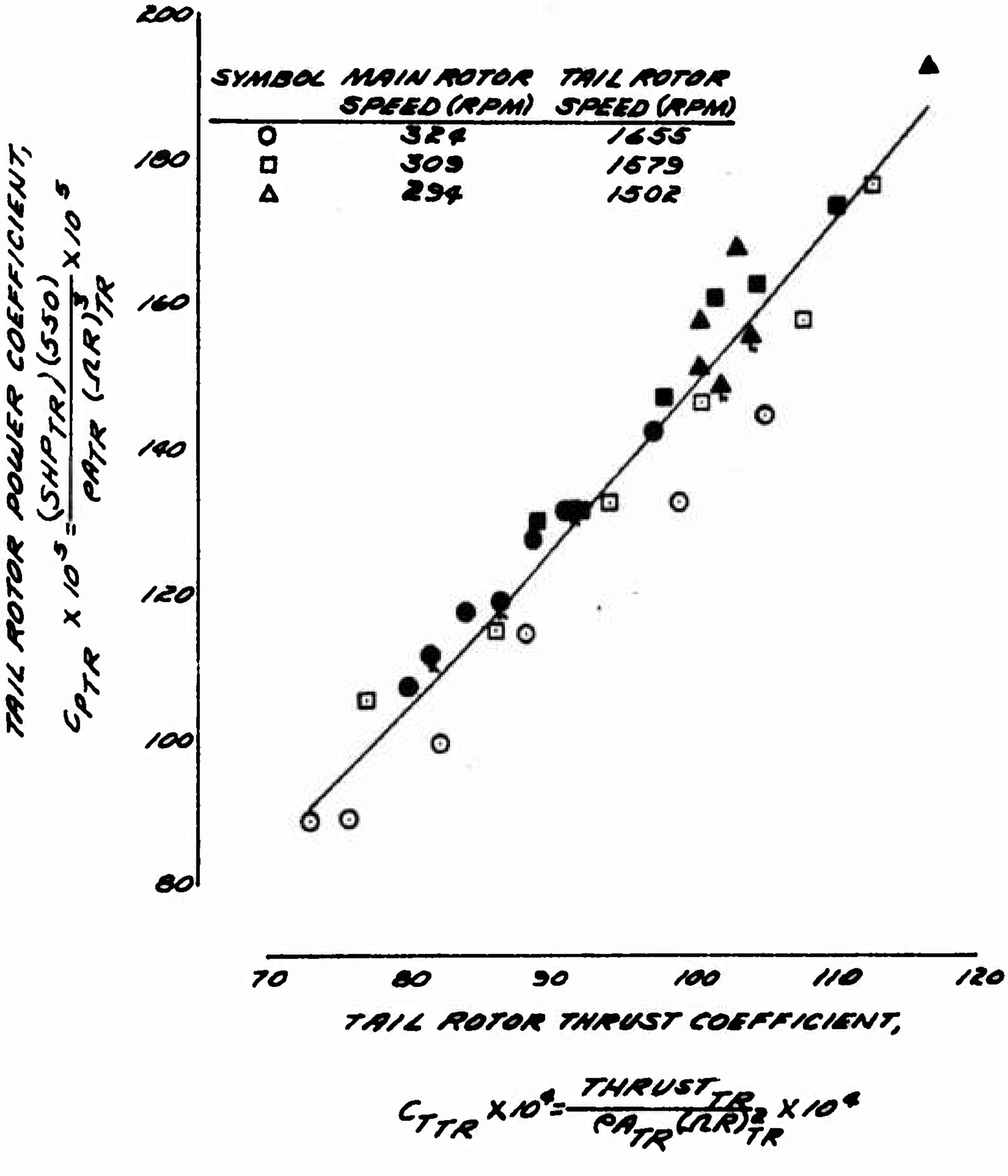


FIGURE 3

NON-DIMENSIONAL TAIL ROTOR PERFORMANCE

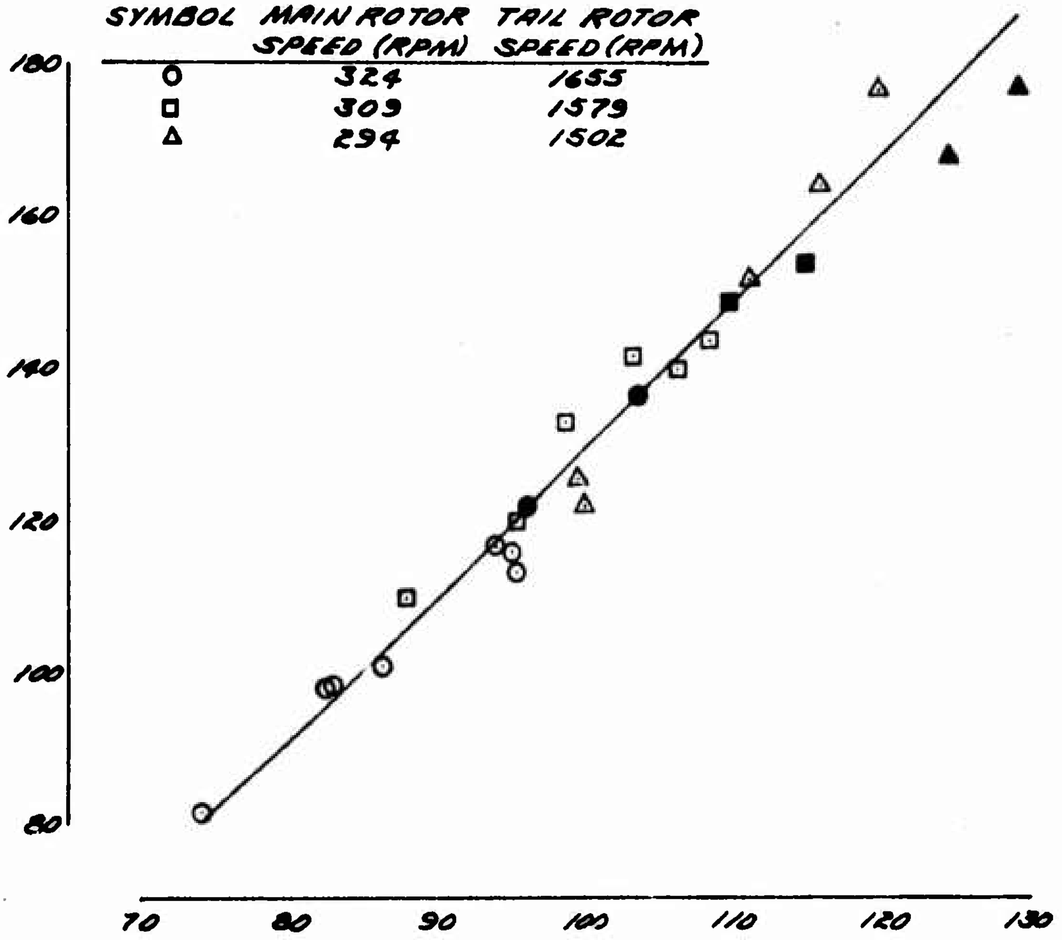
AH-1G USA S/N 71-20985

OGE SKID HEIGHT = 100 FEET

NOTES:

1. OPEN SYMBOLS DENOTE:
   DENSITY ALTITUDE OF 3760 FT.
   AIR TEMPERATURE OF 22.5 °C.
   TETHERED HOVER METHOD.
2. SOLID SYMBOLS DENOTE:
   DENSITY ALTITUDE OF 11760 FT.
   AIR TEMPERATURE OF 15.0 °C.
   FREE FLIGHT HOVER METHOD.

| SYMBOL | MAIN ROTOR SPEED (RPM) | TAIL ROTOR SPEED (RPM) |
|---|---|---|
| ○ | 324 | 1655 |
| □ | 309 | 1579 |
| △ | 294 | 1502 |




TAIL ROTOR POWER COEFFICIENT,

$$C_{P_{TR}} \times 10^5 = \frac{(SHP_{TR})(550)}{\rho A_{TR}(\Omega R)^3_{TR}} \times 10^5$$

TAIL ROTOR THRUST COEFFICIENT,

$$C_{T_{TR}} \times 10^4 = \frac{THRUST_{TR}}{\rho A_{TR}(\Omega R)^2_{TR}} \times 10^4$$

FIGURE 9

MILITARY RATED SHAFT HORSEPOWER AVAILABLE

T53-L-13 ENGINE

HOVER.

NOTES:

1. DATA BASED ON LYCOMING T53-L-13 ENGINE MODEL SPECIFICATION NUMBER 104.33.
2. ENGINE PARTICLE SEPARATOR INSTALLED.
3. ROTOR SPEED = 324 RPM.
4. COMPRESSOR INLET TEMPERATURE RISE = 3°C.
5. COMPRESSOR INLET PRESSURE LOSS = 0.985.
6. GENERATOR ELECTRICAL LOAD = ZERO.
7. AIRBLEED = 0.6 %.

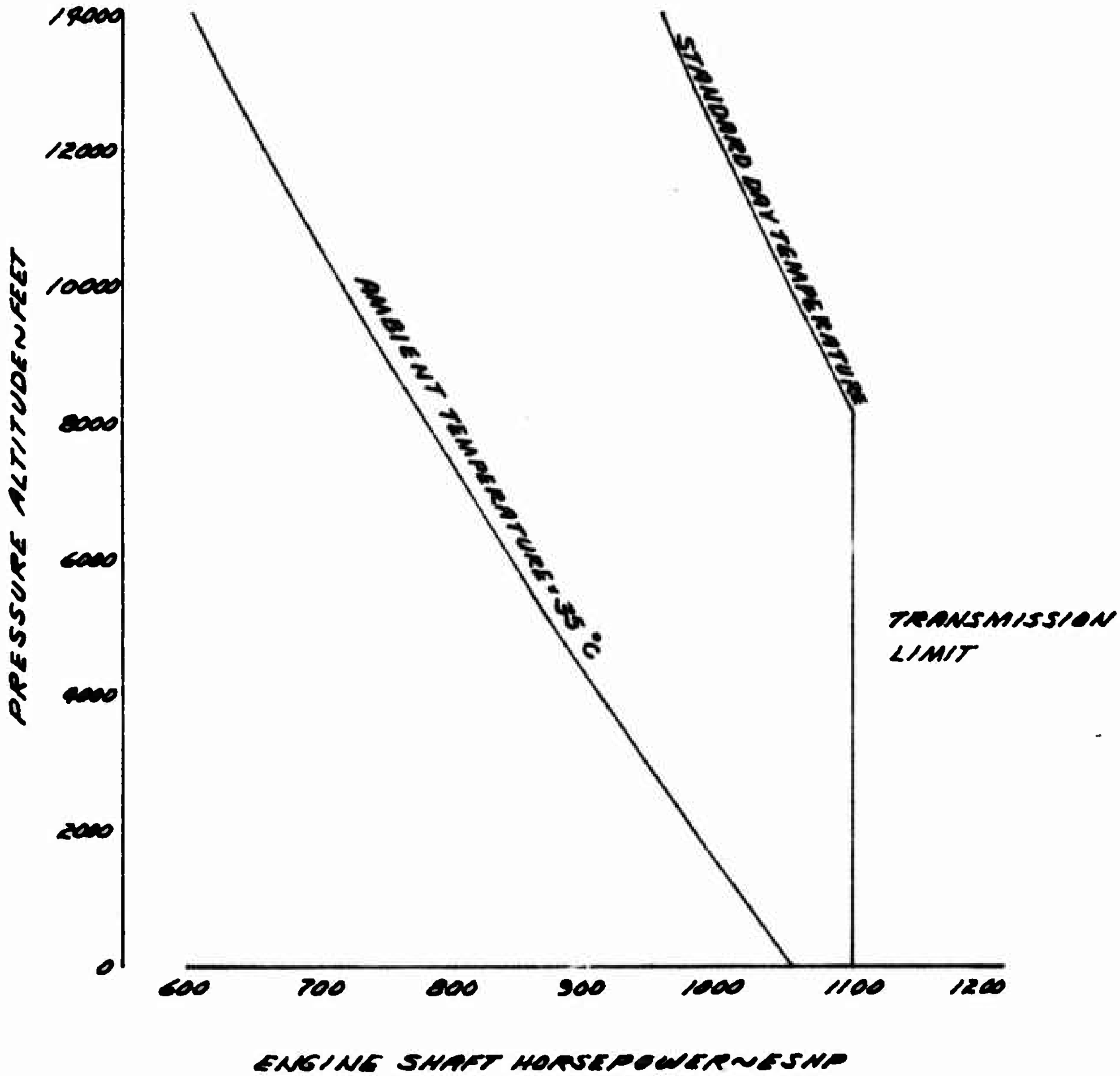


FIGURE 10

**LEVEL FLIGHT PERFORMANCE**

AH-1G USA S/N 71-20985

| GROSS WEIGHT (LB) | DENSITY ALTITUDE (FT) | OAT (°C) | CG LOCATION (IN) | ROTOR SPEED (RPM) | $C_T$ | CONFIG |
|---|---|---|---|---|---|---|
| 7760 | 5080 | 13.0 | 193.5 | 324 | .004485 | HOG |

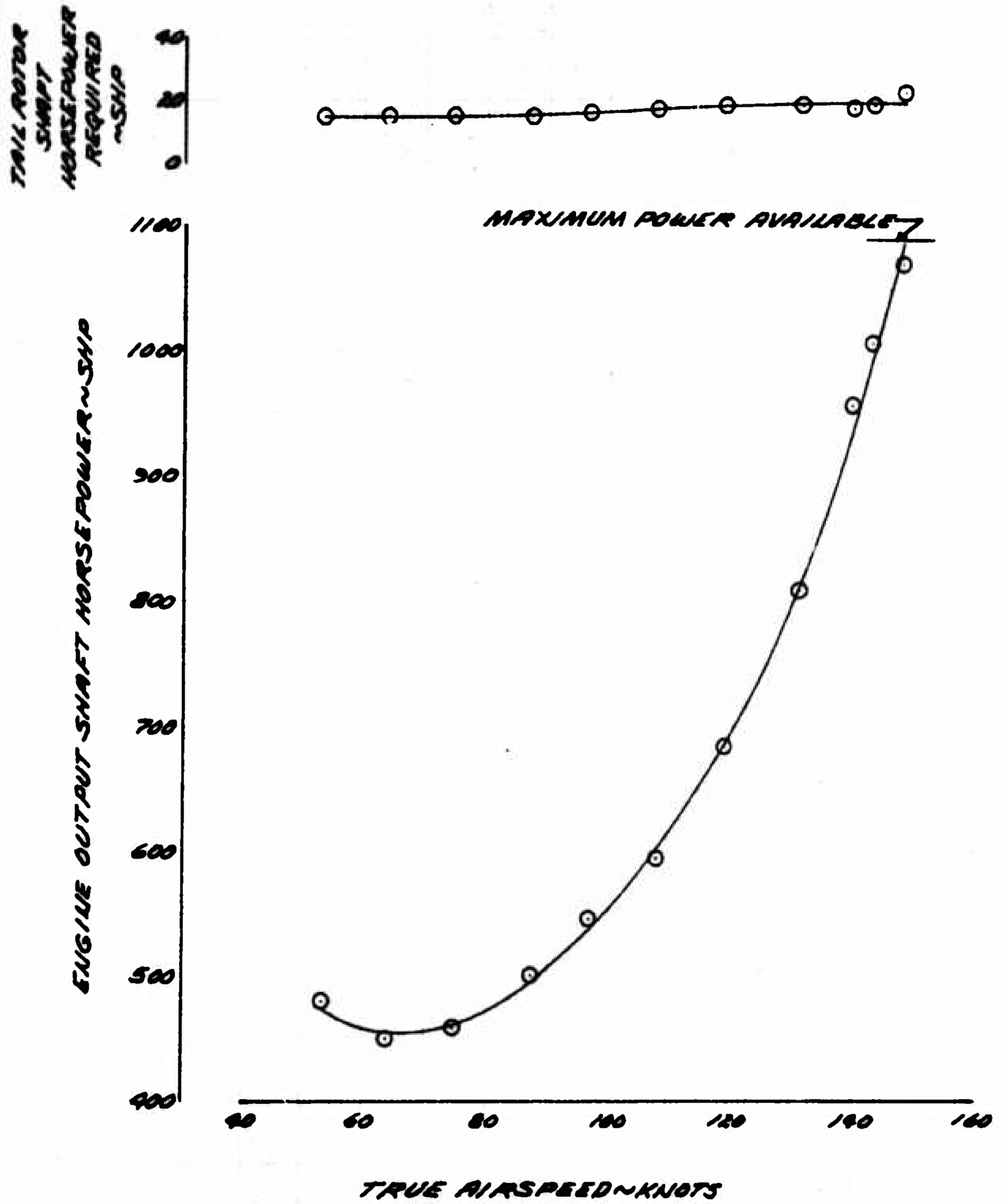


FIGURE 11

**LEVEL FLIGHT PERFORMANCE**

AH-1G USA S/N 71-20985

| GROSS WEIGHT (LB) | DENSITY ALTITUDE (FT) | OAT (°C) | CG LOCATION (IN.) | ROTOR SPEED (RPM) | $C_T$ | CONFIG |
|---|---|---|---|---|---|---|
| 9050 | 7580 | 23.0 | 193.5 | 324 | .003645 | HOG |

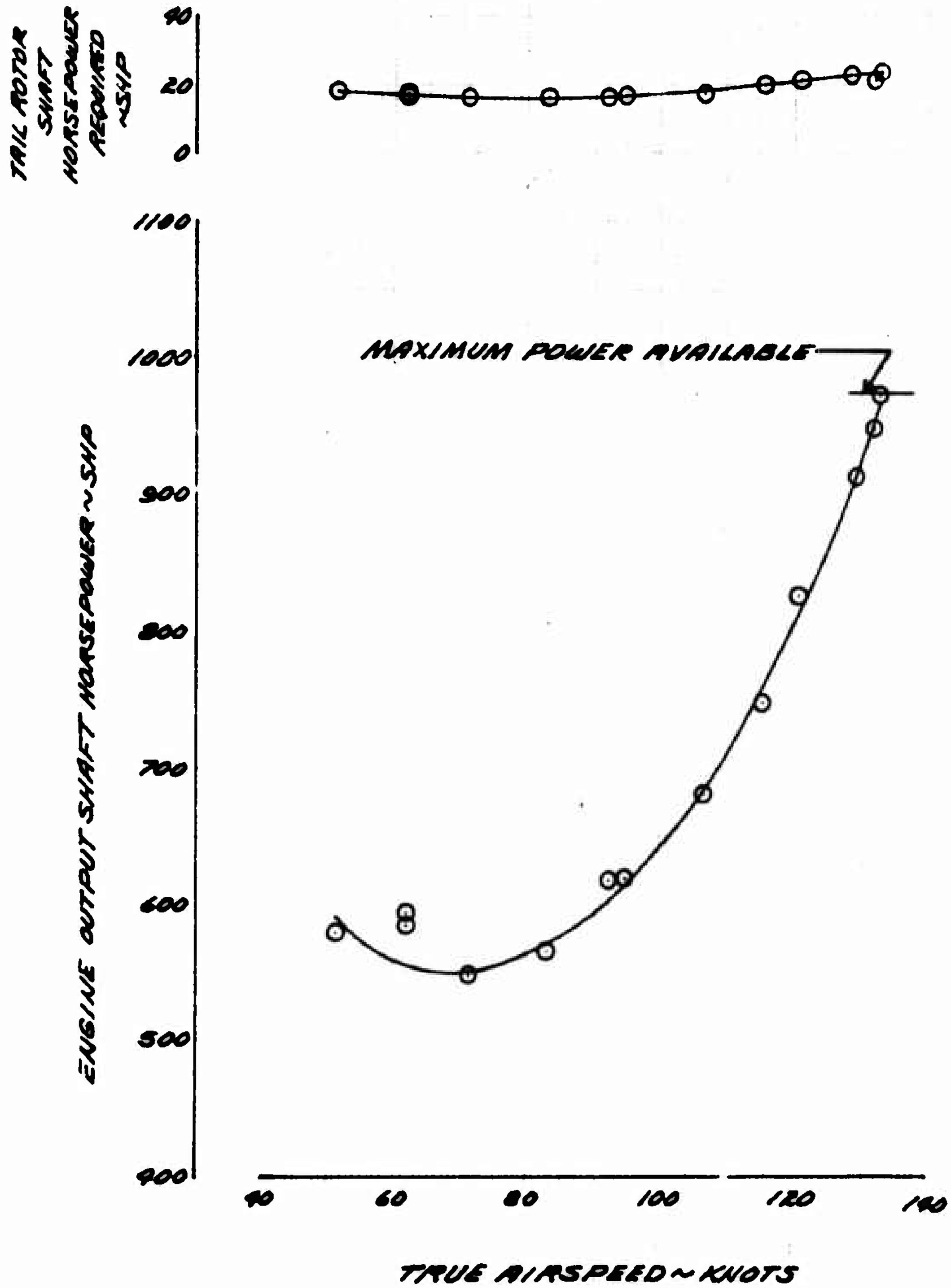


FIGURE 12

**LONGITUDINAL CONTROL SYSTEM CHARACTERISTICS**

AH-1G USA S/N 71-20988

**NOTES:**

1. ROTOR STATIC.
2. CYCLIC FRICTION AT MANUFACTURER'S PRE-SET VALUE.
3. HYDRAULIC AND ELECTRICAL POWER PROVIDED BY GROUND UNITS.
4. HYDRAULIC BOOST SYSTEMS ON.
5. LATERAL CONTROL POSITION CENTERED DURING TEST.
6. SHADED SYMBOLS DENOTE TRIM POINTS.
7. CONTROL FORCES MEASURED AT CENTER OF GRIP.

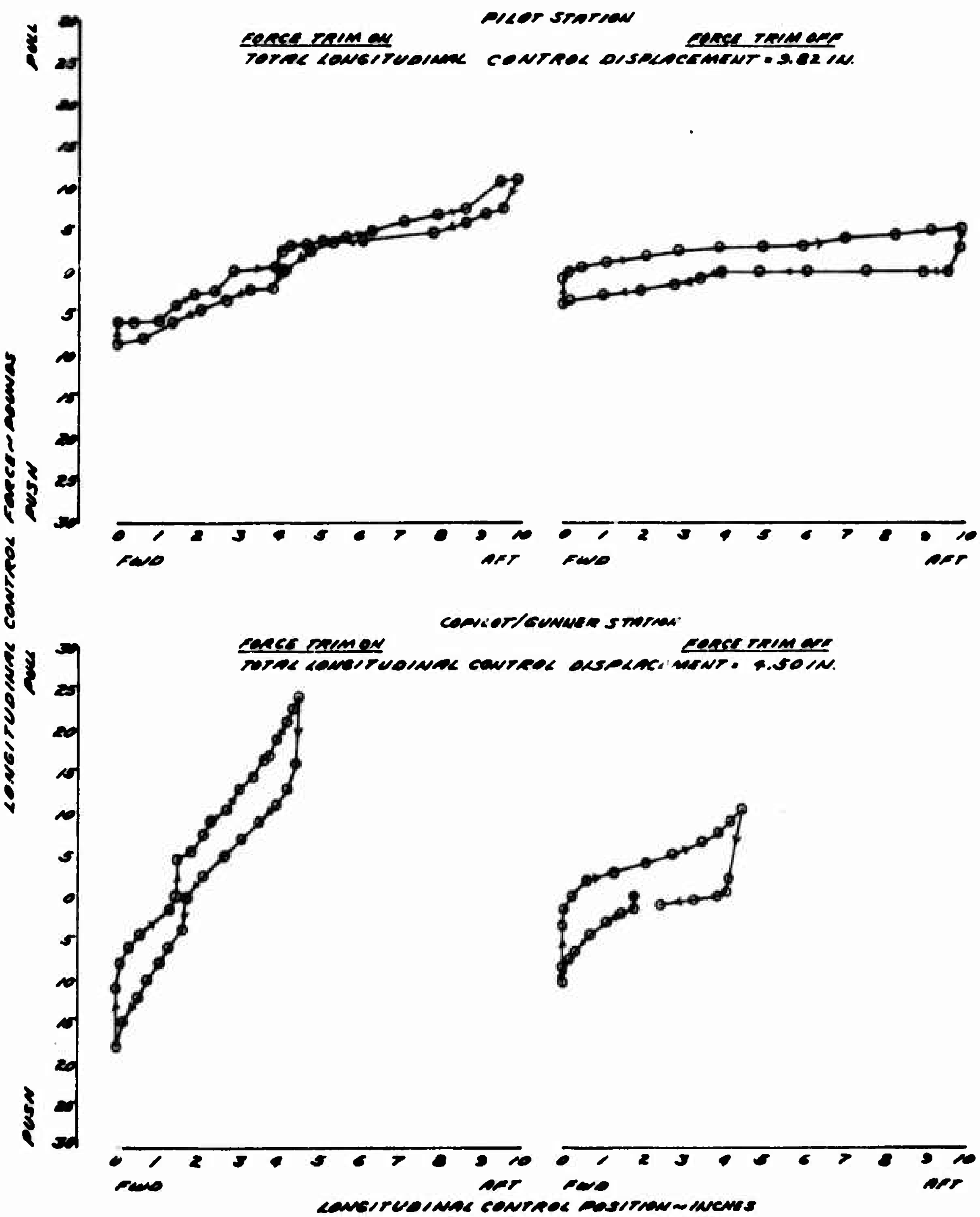


FIGURE 13

**LATERAL CONTROL SYSTEM CHARACTERISTICS**

**AH-1G USA S/N 71-20986**

**NOTES:**

1. ROTOR STATIC.
2. CYCLIC FRICTION AT MANUFACTURER'S PRE-SET VALUE.
3. HYDRAULIC AND ELECTRICAL POWER PROVIDED BY GROUND UNITS.
4. HYDRAULIC BOOST SYSTEMS ON.
5. LONGITUDINAL CONTROL POSITION CENTERED DURING TEST.
6. SHADED SYMBOLS DENOTE TRIM POINTS.
7. CONTROL FORCES MEASURED AT CENTER OF GRIP

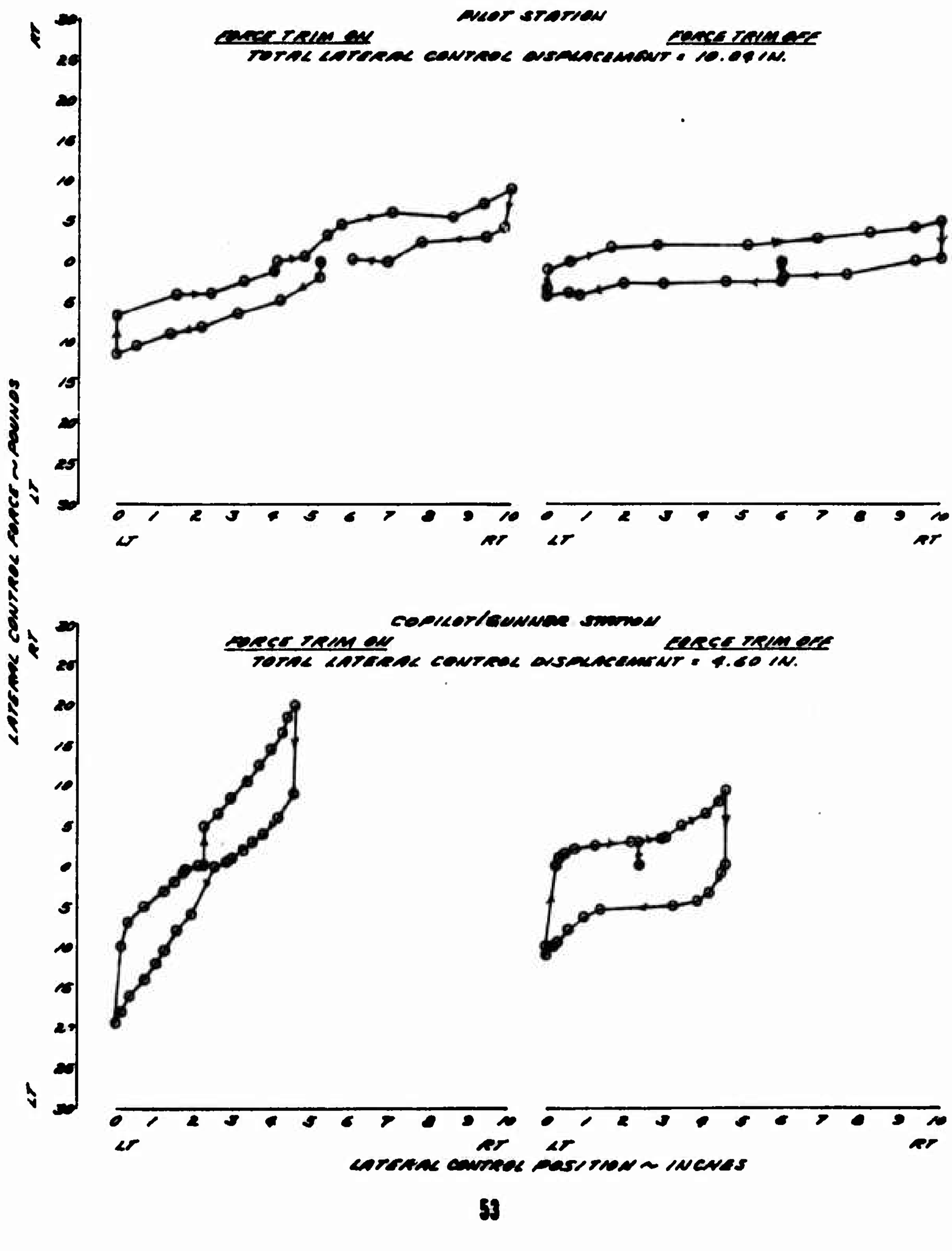


**FIGURE 19**

**DIRECTIONAL CONTROL SYSTEM CHARACTERISTICS**

**AH-1G USA S/N 71-20985**

**NOTES:**

1. ROTOR STATIC.
2. HYDRAULIC AND ELECTRICAL POWER PROVIDED BY GROUND UNITS.
3. CYCLIC CONTROL CENTERED.
4. SHADED SYMBOLS DENOTE TRIM POINTS.
5. CONTROL FORCES MEASURED AT CENTER OF PEDAL.

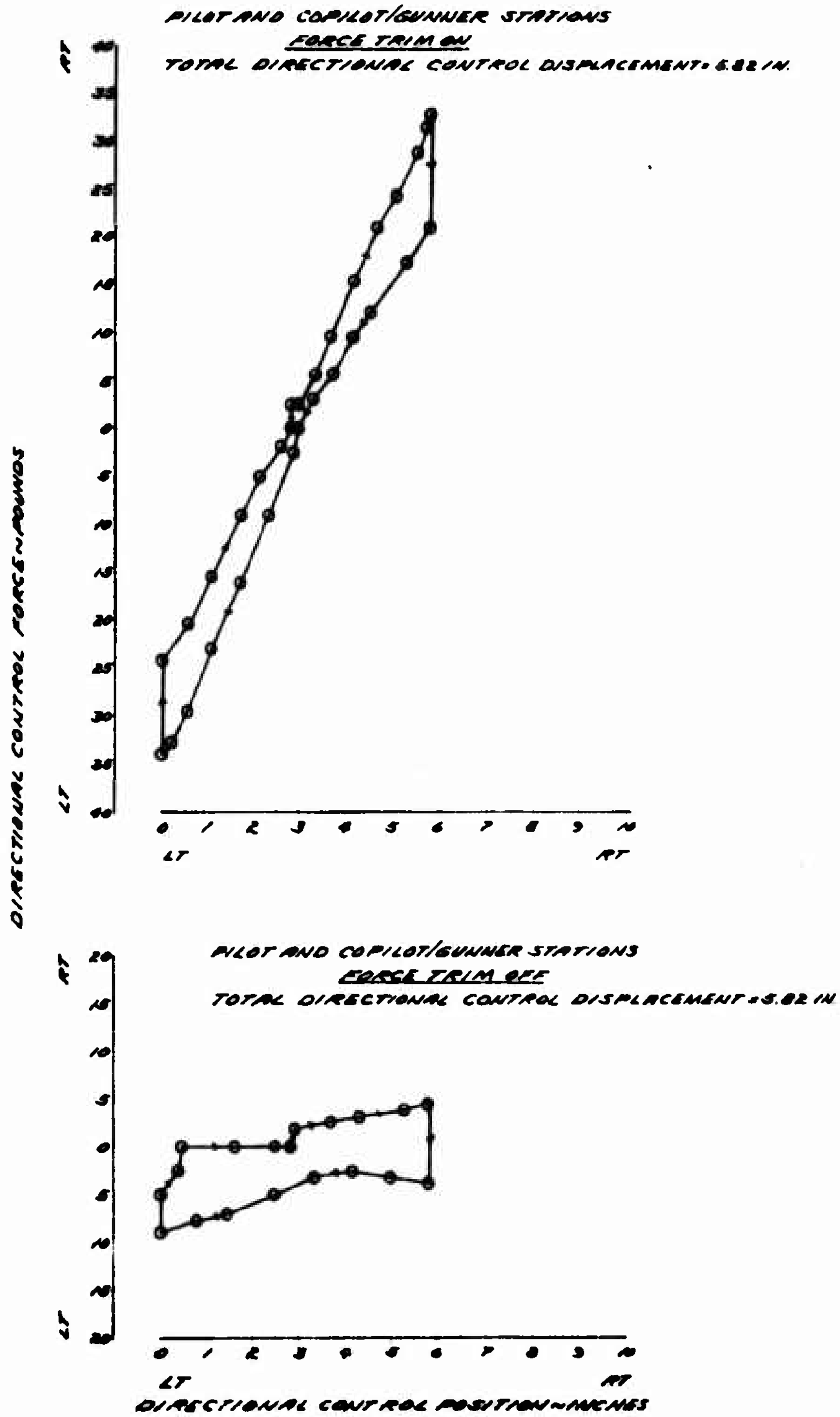


FIGURE 15

COLLECTIVE CONTROL SYSTEM CHARACTERISTICS

AH-1G USA S/N 71-20985

NOTES:

1. ROTOR STATIC.
2. HYDRAULIC AND ELECTRICAL POWER PROVIDED BY GROUND UNIT.
3. HYDRAULIC BOOST SYSTEMS ON.
4. CYCLIC CONTROL CENTERED.
5. SHADED SYMBOLS DENOTE TRIM POINTS.
6. CONTROL FORCES MEASURED AT CENTER OF GRIP.

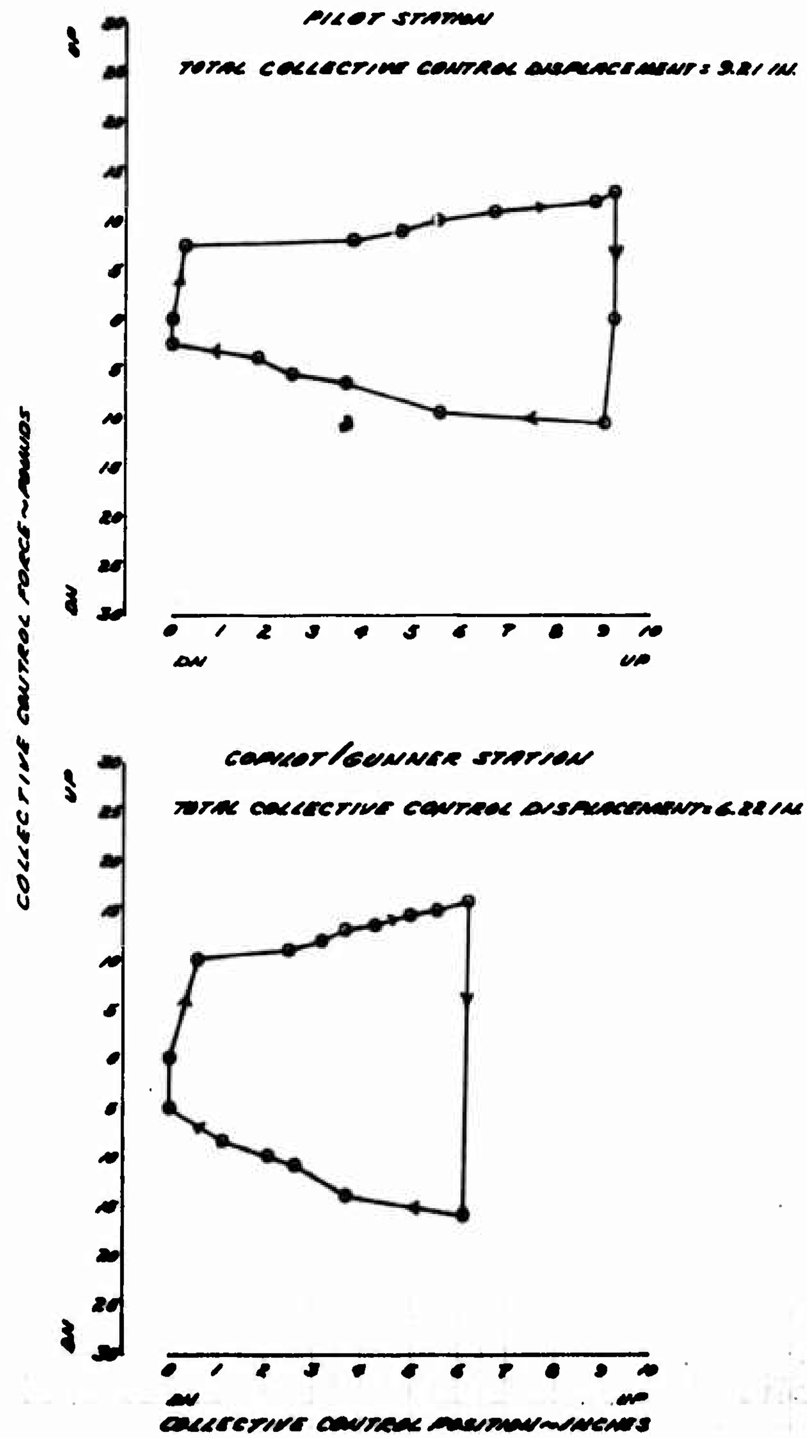


FIGURE 16

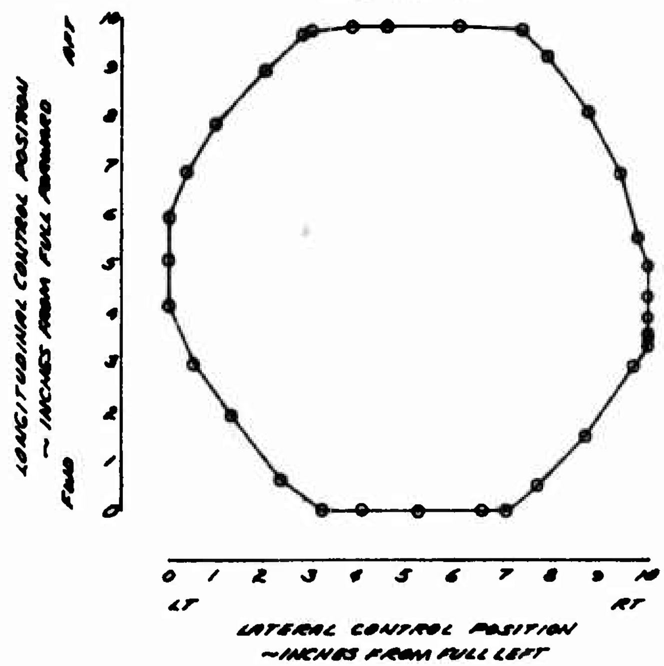
CYCLIC PITCH CONTROL PATTERN

AH-1G USA S/N 71-20985

NOTES:

1. ROTOR STATIC.
2. HYDRAULIC AND ELECTRICAL POWER PROVIDED BY GROUND UNITS.
3. HYDRAULIC BOOST SYSTEMS ON.
4. DIRECTIONAL CONTROL POSITION = 2.30 INCHES FROM FULL LEFT.
5. COLLECTIVE CONTROL POSITION DID NOT ALTER CYCLIC MOVEMENT LIMITS.
6. TOTAL CONTROL DISPLACEMENT:
   - LONGITUDINAL = 9.82 INCHES. (PILOT)
   - LATERAL = 10.04 INCHES. (PILOT)
   - LONGITUDINAL = 4.50 INCHES. (COPILOT/GUNNER)
   - LATERAL = 4.60 INCHES. (COPILOT/GUNNER)

PILOT STATION




COPILOT/GUNNER STATION

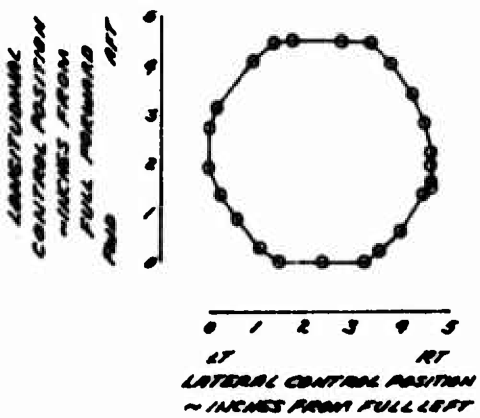


FIGURE 1.7
CONTROL POSITIONS IN TRIMMED FORWARD FLIGHT
AH-1G USA S/N 71-20985

| FLIGHT CONDITION | AVG GROSS WEIGHT (LB) | AVG DENSITY ALTITUDE (FT) | AVG OAT (°C) | AVG CG LOCATION (IN.) | AVG ROTOR SPEED (RPM) | AVG $C_T$ |
|---|---|---|---|---|---|---|
| LEVEL | 7760 | 5080 | 13.0 | 193.5 | 323 | .004483 |

HOG CONFIGURATION

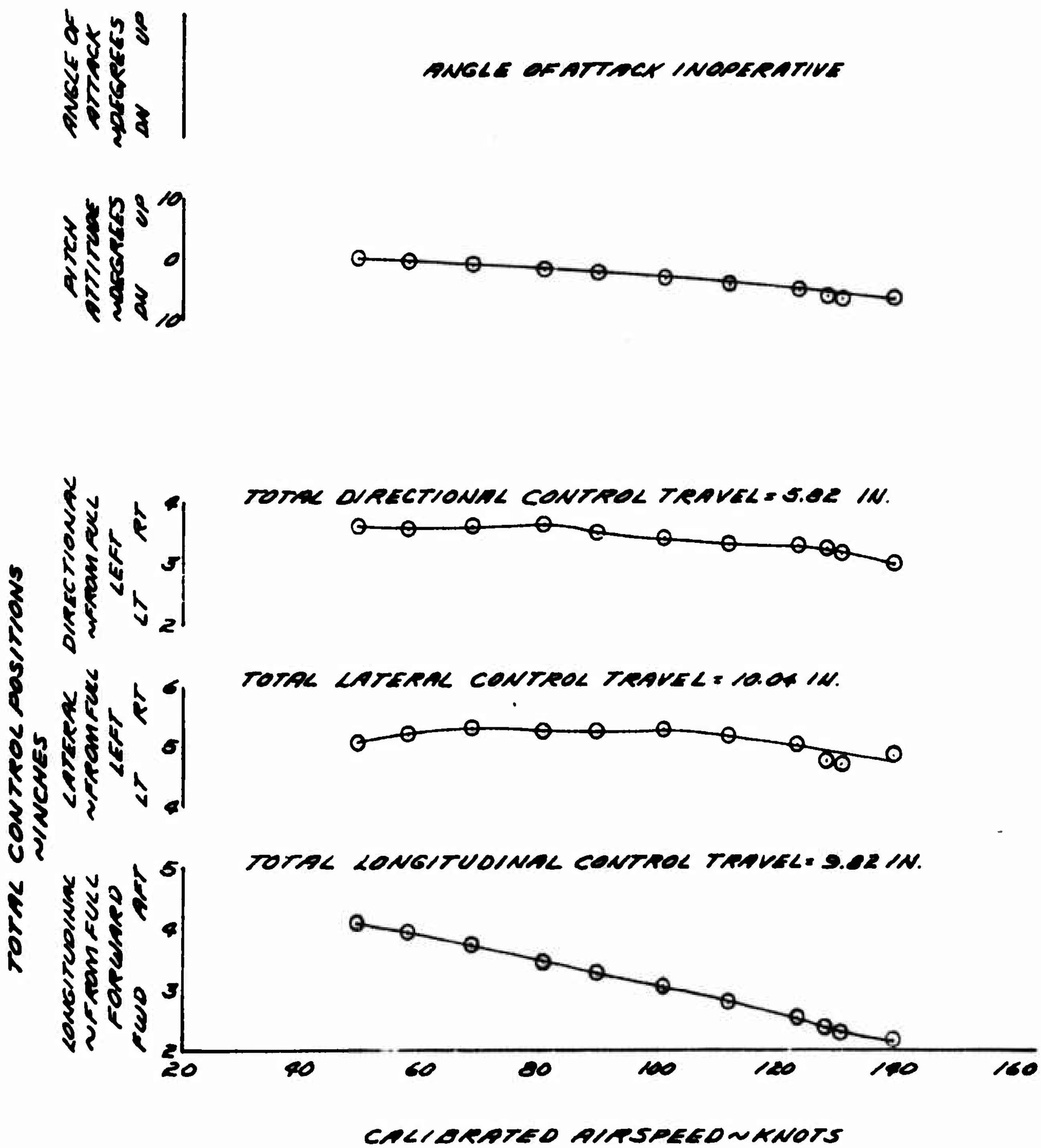


FIGURE 18

CONTROL POSITIONS IN TRIMMED FORWARD FLIGHT

AH-1G USA S/N 71-20985

| FLIGHT CONDITION | AVG GROSS WEIGHT (LB) | AVG DENSITY ALTITUDE (FT) | AVG OAT (°C) | AVG CG LOCATION (IN.) | AVG ROTOR SPEED (RPM) | AVG $C_T$ |
|---|---|---|---|---|---|---|
| LEVEL | 8620 | 5000 | 25.0 | 193.6 | 324 | .004968 |

HOG CONFIGURATION

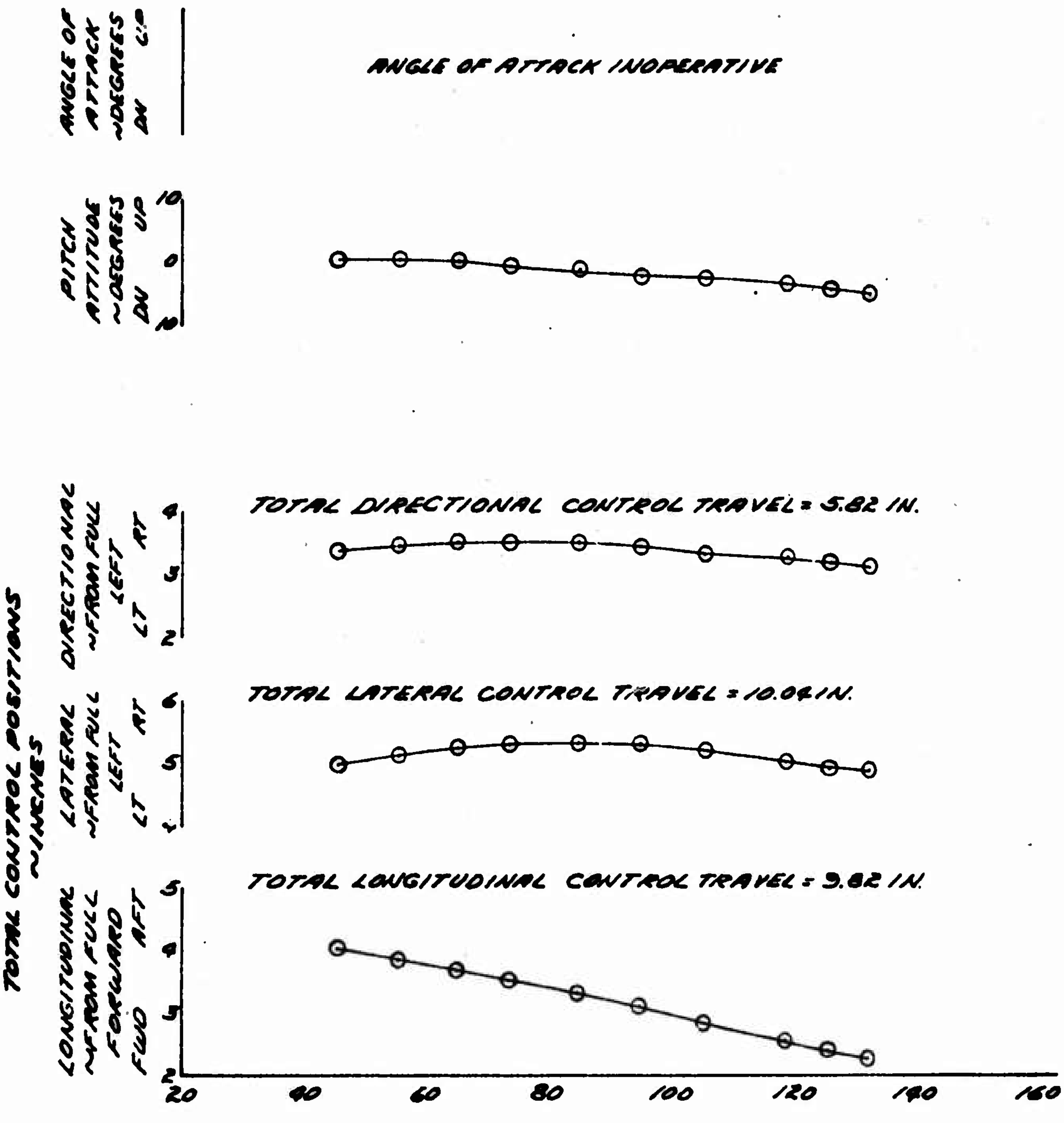


FIGURE 13

CONTROL POSITIONS IN TRIMMED FORWARD FLIGHT

AH-1G USA S/N 71-20985

| SYMBOL | FLIGHT CONDITION | AVG GROSS WEIGHT (LB) | AVG DENSITY ALTITUDE (FT) | AVG OAT (°C) | AVG CG LOCATION (IN.) | AVG ROTOR SPEED (RPM) | AVG $C_T$ |
|---|---|---|---|---|---|---|---|
| O | CLIMB | 8830 | 4880 | 25.0 | 193.6 | 324 | .005063 |
| □ | AUTO | 8810 | 4580 | 35.0 | 193.6 | 324 | .005013 |

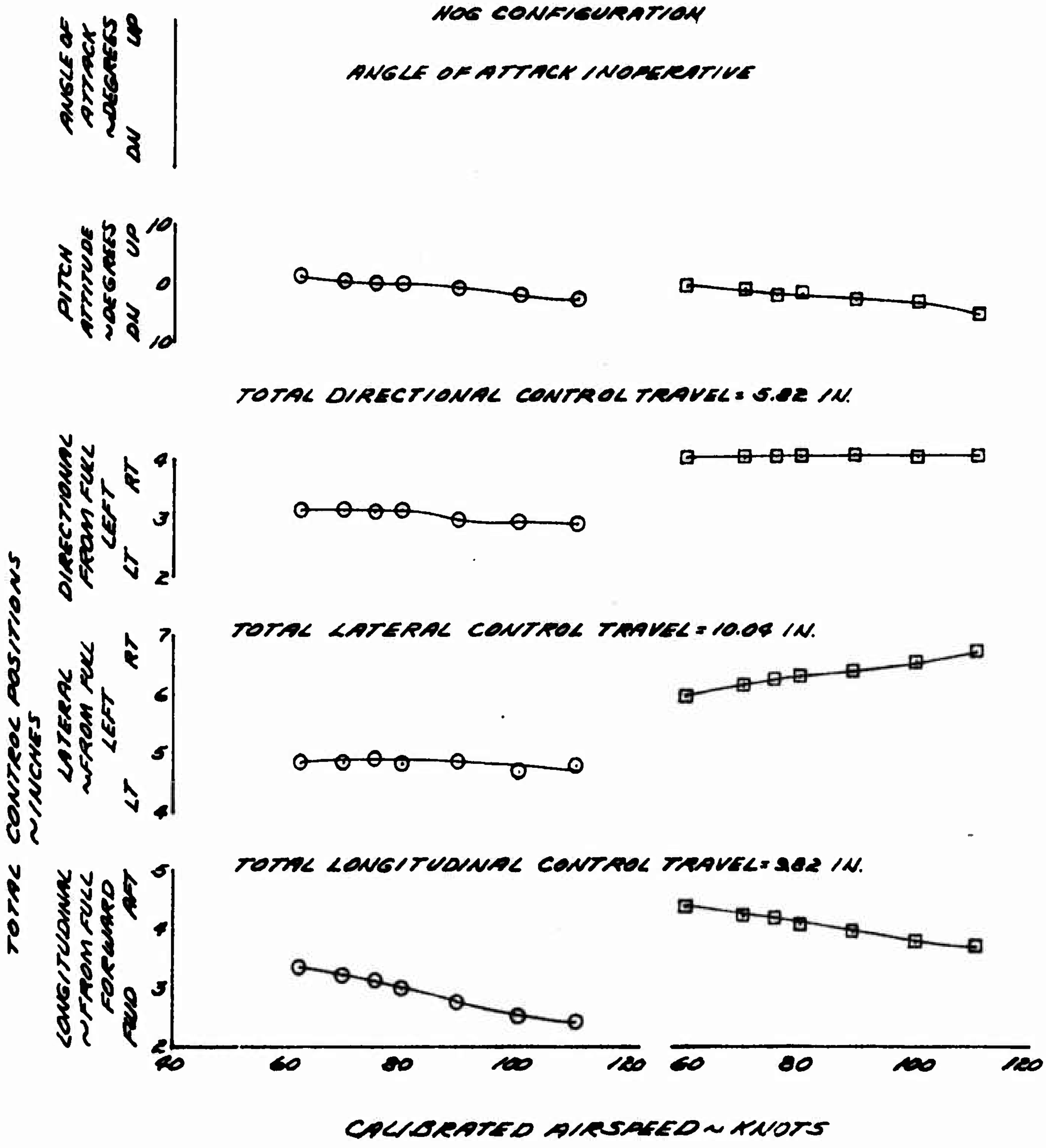


FIGURE 20

STATIC LONGITUDINAL STABILITY

AH-1G USA S/N 71-20985

| SYMBOL | FLIGHT CONDITION | AVG GROSS WEIGHT (LB) | AVG DENSITY ALTITUDE (FT) | AVG OAT (°C) | AVG CG LOCATION (IN.) | AVG ROTOR SPEED (RPM) | AVG $C_T$ | CONFIG |
|---|---|---|---|---|---|---|---|---|
| ○ | LEVEL | 8870 | 4660 | 21.5 | 193.7 | 324 | .005060 | HOG |
| □ | LEVEL | 8780 | 6060 | 22.0 | 193.6 | 324 | .005049 | HOG |
| △ | LEVEL | 8740 | 6020 | 26.5 | 193.6 | 324 | .005090 | HOG |

NOTES:

1. COLLECTIVE CONTROL POSITION HELD FIXED DURING TEST.
2. SHADED SYMBOLS DENOTE TRIM POINTS.

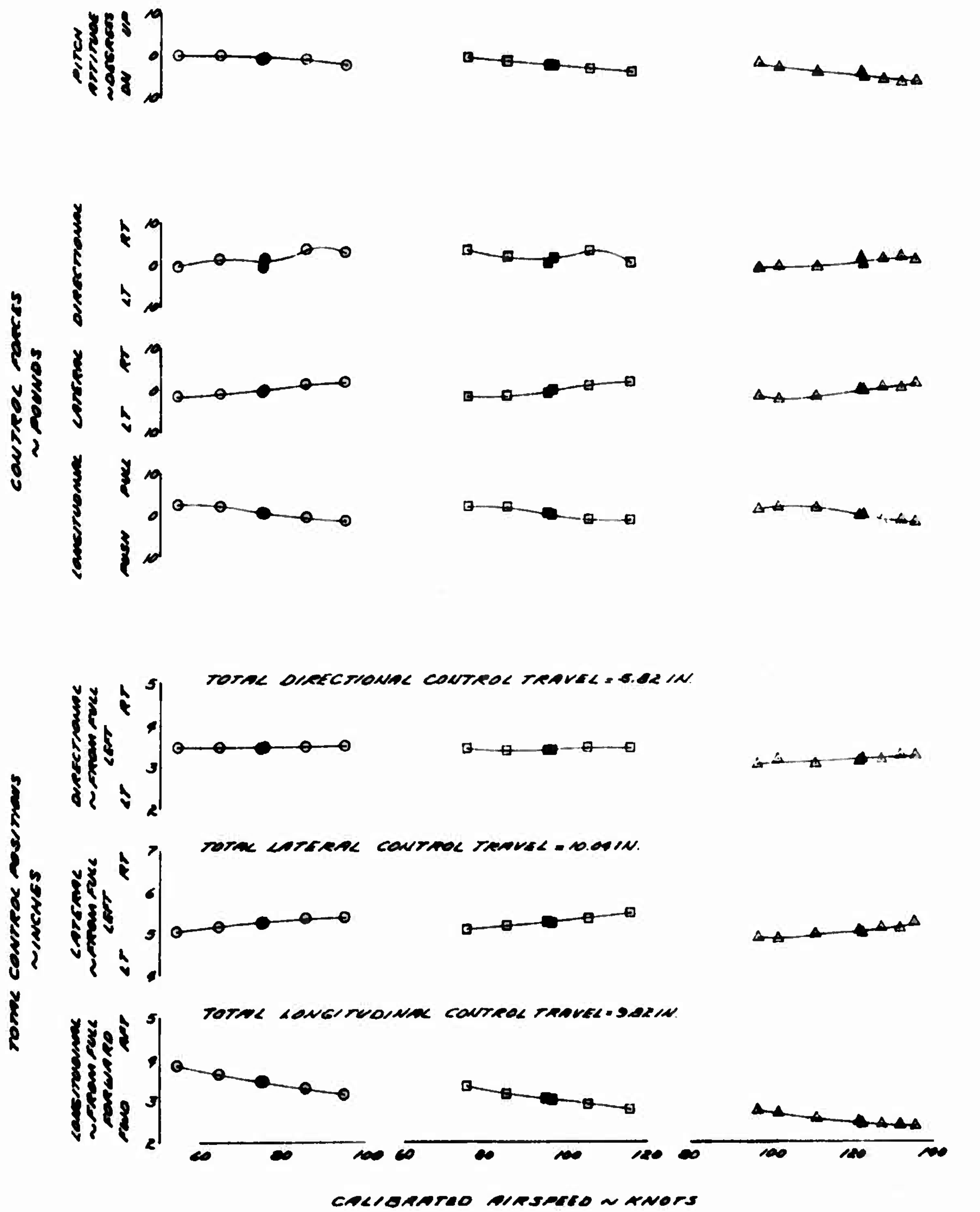


FIGURE 21

STATIC LONGITUDINAL STABILITY

AH-1G USA S/N 71-20985

| SYMBOL | FLIGHT CONDITION | AVG GROSS WEIGHT (LB) | AVG DENSITY ALTITUDE (FT) | AVG OAT (°C) | AVG CG LOCATION (IN.) | ROTOR SPEED (RPM) | AVG $C_T$ | CONFIG |
|---|---|---|---|---|---|---|---|---|
| ○ | CLIMB | 8570 | 5500 | 26.0 | 193.6 | 324 | .005010 | HOG |
| □ | AUTO | 8380 | 5900 | 26.5 | 193.4 | 323 | .004913 | HOG |

NOTES:
1. COLLECTIVE CONTROL POSITION HELD FIXED DURING TEST.
2. SHADED SYMBOLS DENOTE TRIM POINTS.

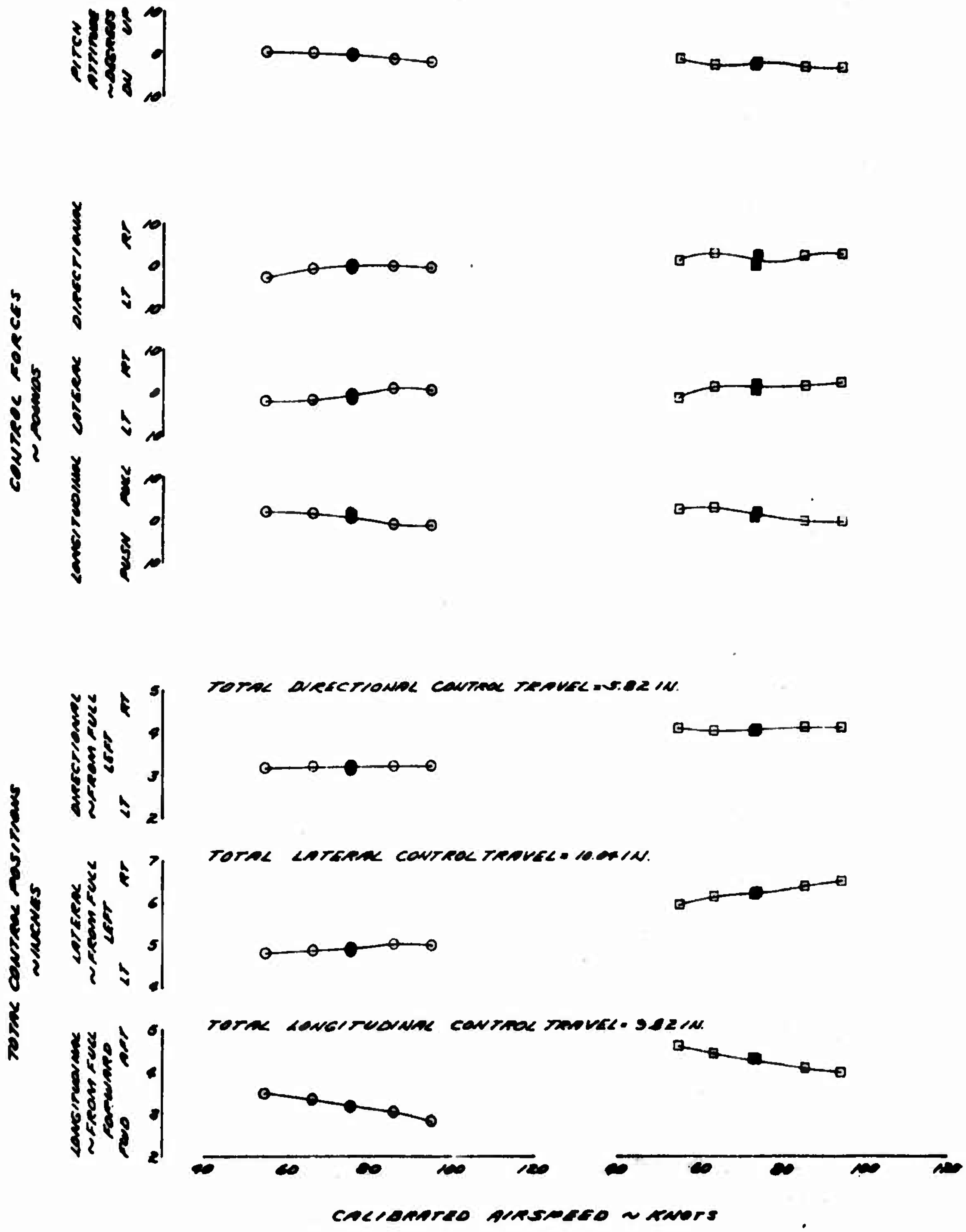


FIGURE 22
STATIC LATERAL-DIRECTIONAL STABILITY
AH-1G USA S/N 71-20985

| SYMBOL | FLIGHT CONDITION | AVG GROSS WEIGHT (LB) | AVG DENSITY ALTITUDE (FT) | AVG OAT (°C) | AVG CG LOCATION (IN) | AVG ROTOR SPEED (RPM) | AVG $C_T$ | AVG TRIM AIRSPEED KCAS | CONFIG |
|---|---|---|---|---|---|---|---|---|---|
| ○ | LEVEL | 8760 | 4840 | 26.0 | 193.6 | 324 | .004930 | 79 | HOG |
| □ | LEVEL | 8730 | 4780 | 26.6 | 193.5 | 324 | .005032 | 95 | HOG |

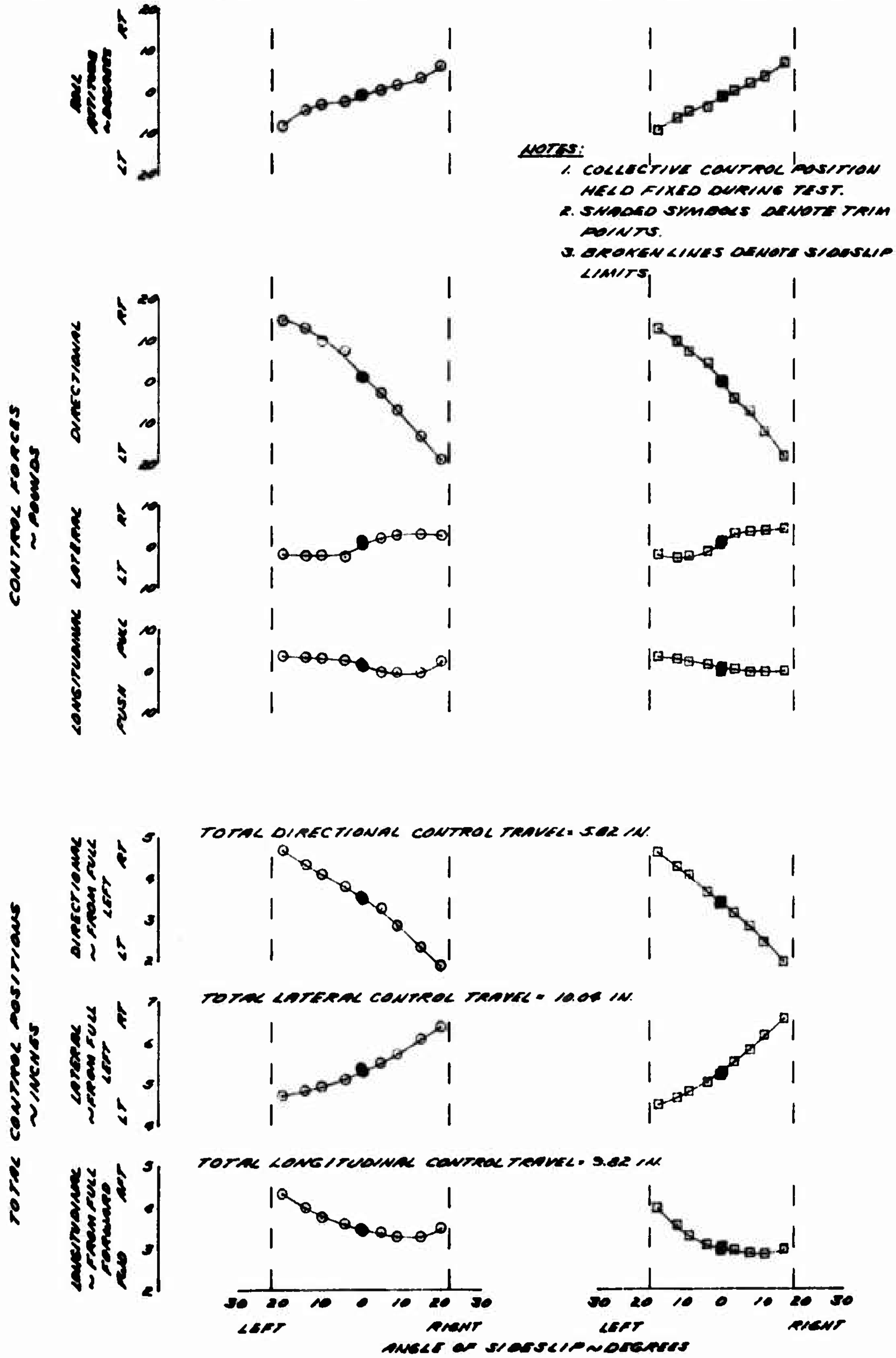


FIGURE 23

STATIC LATERAL-DIRECTIONAL STABILITY

AH-1G USA S/N 71-20985

| SYMBOL | FLIGHT CONDITION | AVG GROSS WEIGHT (LB) | AVG DENSITY ALTITUDE (FT) | AVG OAT (°C) | AVG CG LOCATION (IN.) | AVG ROTOR SPEED (RPM) | AVG $C_T$ | AVG TRIM AIRSPEED (KCAS) | CONFIG |
|---|---|---|---|---|---|---|---|---|---|
| ○ | LEVEL | 8570 | 4860 | 25.0 | 193.5 | 324 | .004318 | 121 | HOG |
| □ | LEVEL | 8340 | 4660 | 26.5 | 193.4 | 329 | .004757 | 133 | HOG |

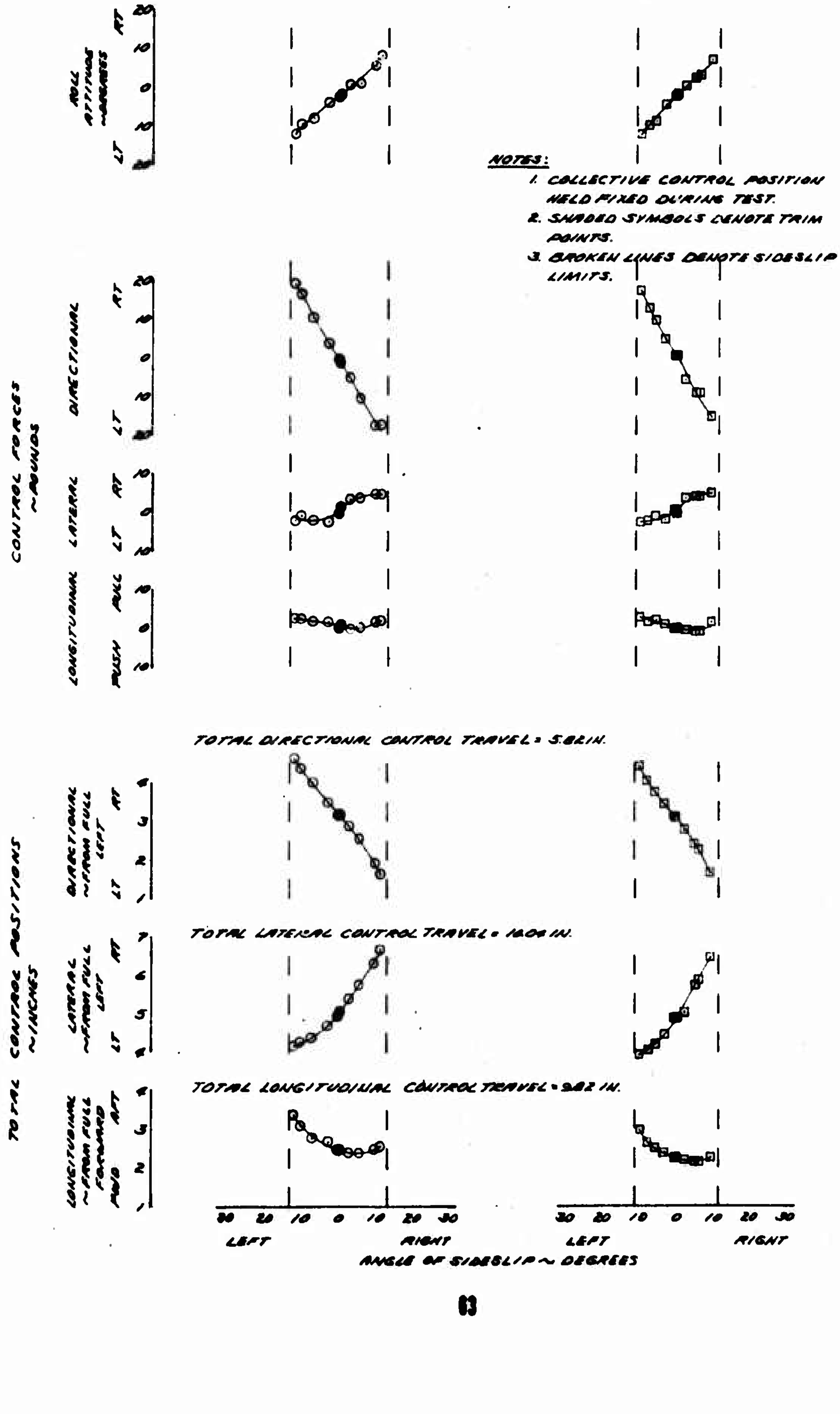


FIGURE 29

STATIC LATERAL-DIRECTIONAL STABILITY

AH-1G USA S/N 71-20985

| SYMBOL | FLIGHT CONDITION | AVG GROSS WEIGHT (LB) | AVG DENSITY ALTITUDE (FT) | AVG OAT (°C) | AVG CG LOCATION (IN) | AVG ROTOR SPEED (RPM) | AVG $C_T$ | AVG TRIM AIRSPEED (KCAS) | CONFIG |
|---|---|---|---|---|---|---|---|---|---|
| ○ | CLIMB | 8730 | 9320 | 25.0 | 193.5 | 324 | .00854 | 75 | HOG |
| □ | AUTO | 8430 | [illegible] | 25.0 | 193.4 | 323 | .00861 | 76 | HOG |

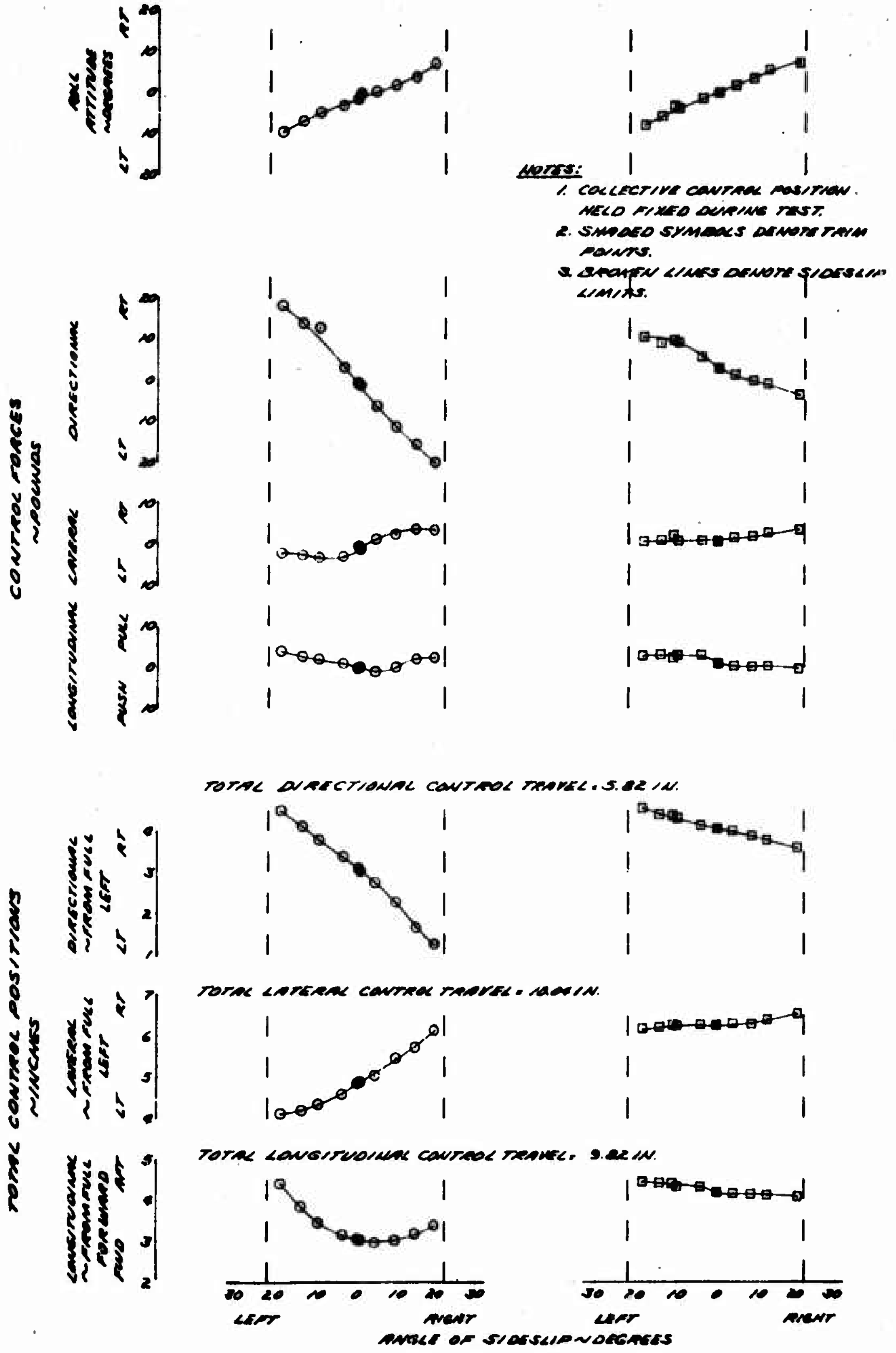


FIGURE 23

SUMMARY DYNAMIC STABILITY

AH-1G USA S/N 71-20985

| SYMBOL | SCAS CONDITION | AVG GROSS WEIGHT (LB) | AVG DENSITY ALTITUDE (FT) | AVG OAT (°C) | AVG CG LOCATION (IN) | AVG ROTOR SPEED (RPM) | AVG $C_T$ | CONFIG |
|---|---|---|---|---|---|---|---|---|
| ○ | ON | 8580 | 4820 | 26.0 | 193.4 | 323 | .004949 | HOG |
| □ | OFF | 8580 | 4560 | 23.0 | 193.6 | 324 | .004879 | HOG |

NOTES:

1. OPEN SYMBOLS DENOTE LEFT INPUT.
2. SOLID SYMBOLS DENOTE RIGHT INPUT.

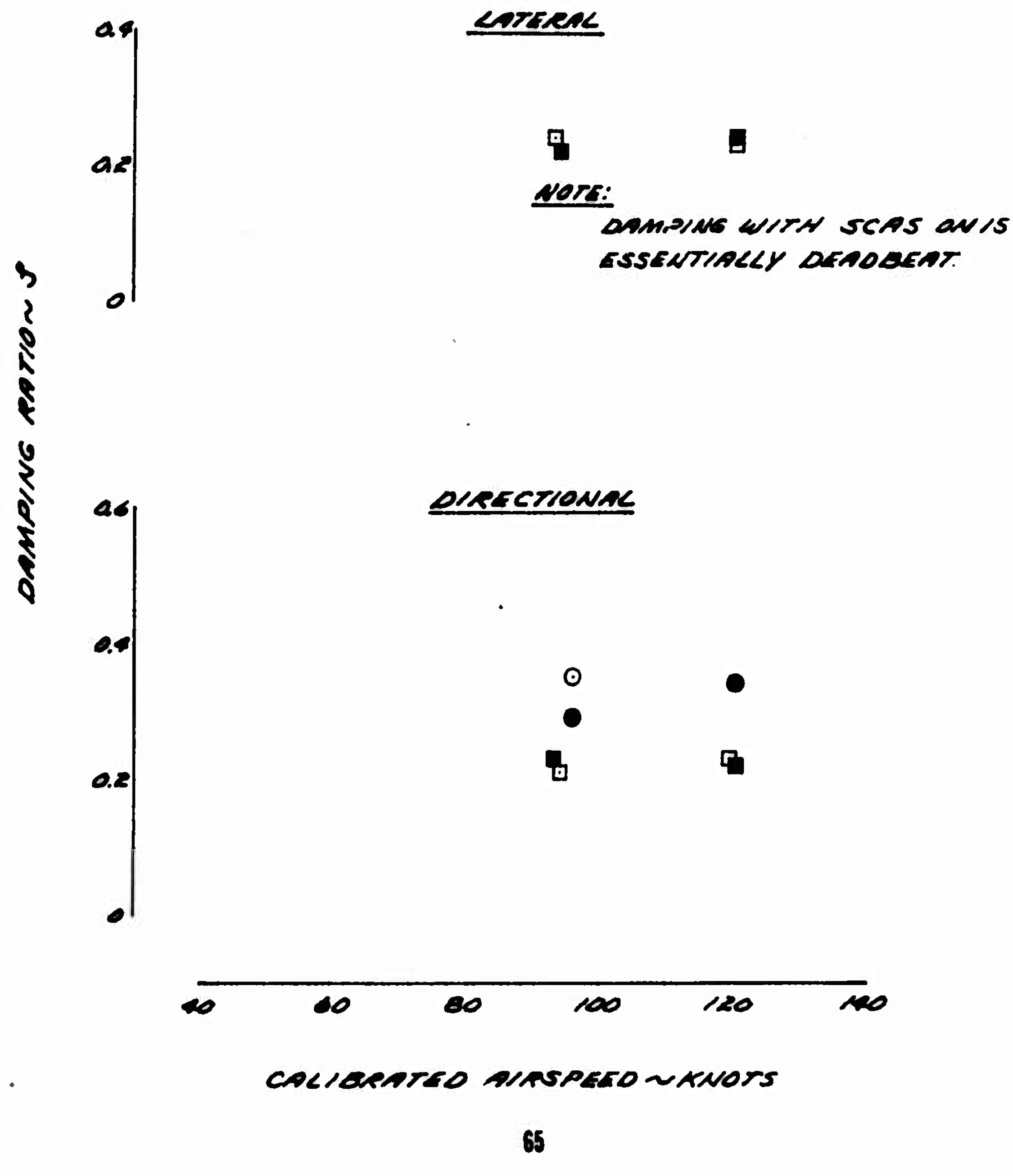


FIGURE 26

**AIRCRAFT RESPONSE FOLLOWING A RIGHT LATERAL PULSE**

AH-1G USA S/N 71-20985

| FLIGHT CONDITION | GROSS WEIGHT (LB) | DENSITY ALTITUDE (FT) | OAT (°C) | CG LOCATION (IN) | ROTOR SPEED (RPM) | $C_T$ | TRIM AIRSPEED (KCAS) | CONFIGURATION |
|---|---|---|---|---|---|---|---|---|
| LEVEL | 8890 | 4860 | 25.0 | 199.6 | 323 | 005184 | 96 | HOG |

NOTE:
SCAS ON

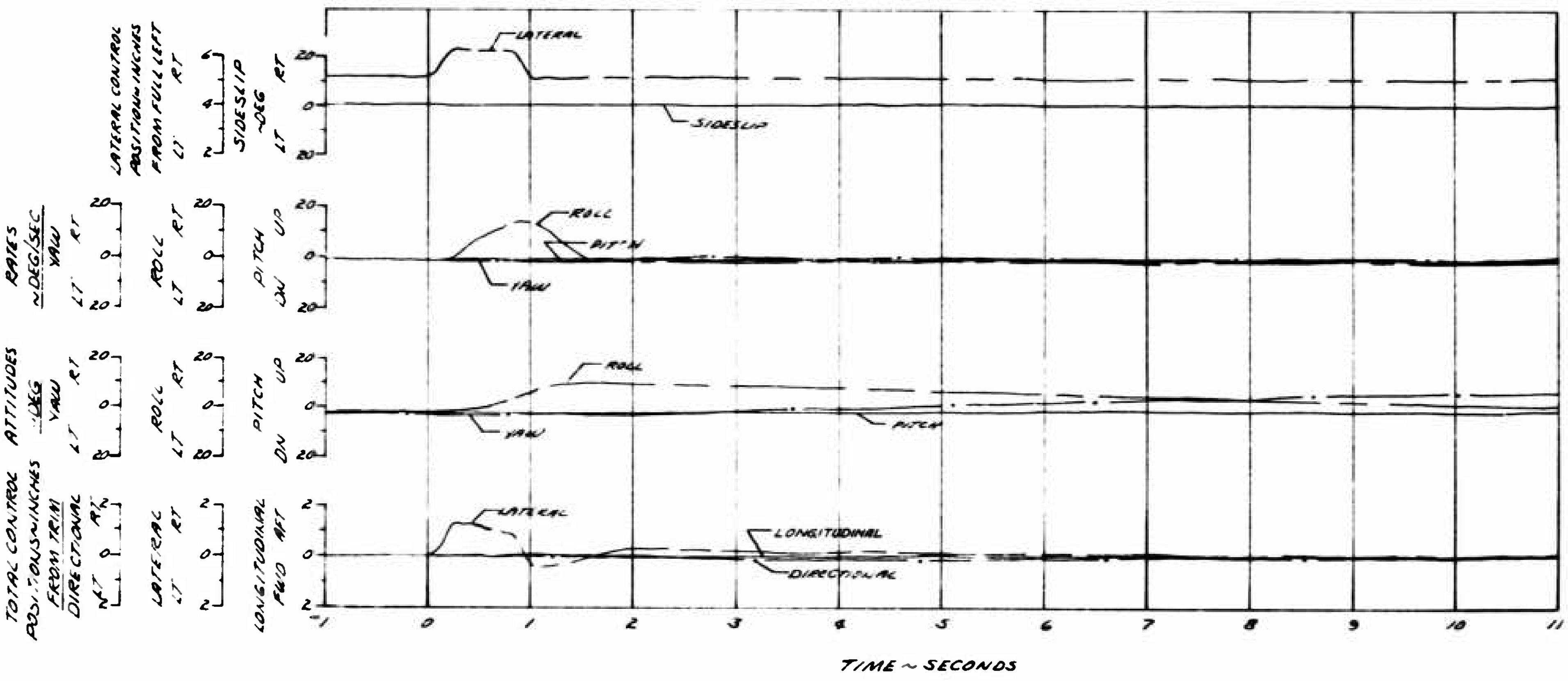


FIGURE 27

AIRCRAFT RESPONSE FOLLOWING A LEFT DIRECTIONAL PULSE

AH-1G USA S/N 71-20985

| FLIGHT CONDITION | GROSS WEIGHT (LB) | DENSITY ALTITUDE (FT) | OAT (°C) | CG LOCATION (IN) | ROTOR SPEED (RPM) | $C_T$ | TRIM AIRSPEED (KCAS) | CONFIGURATION |
|---|---|---|---|---|---|---|---|---|
| LEVEL | 8560 | 4900 | 25.0 | 199.4 | 323 | .004949 | 96 | HOG |

NOTE:
SCAS ON

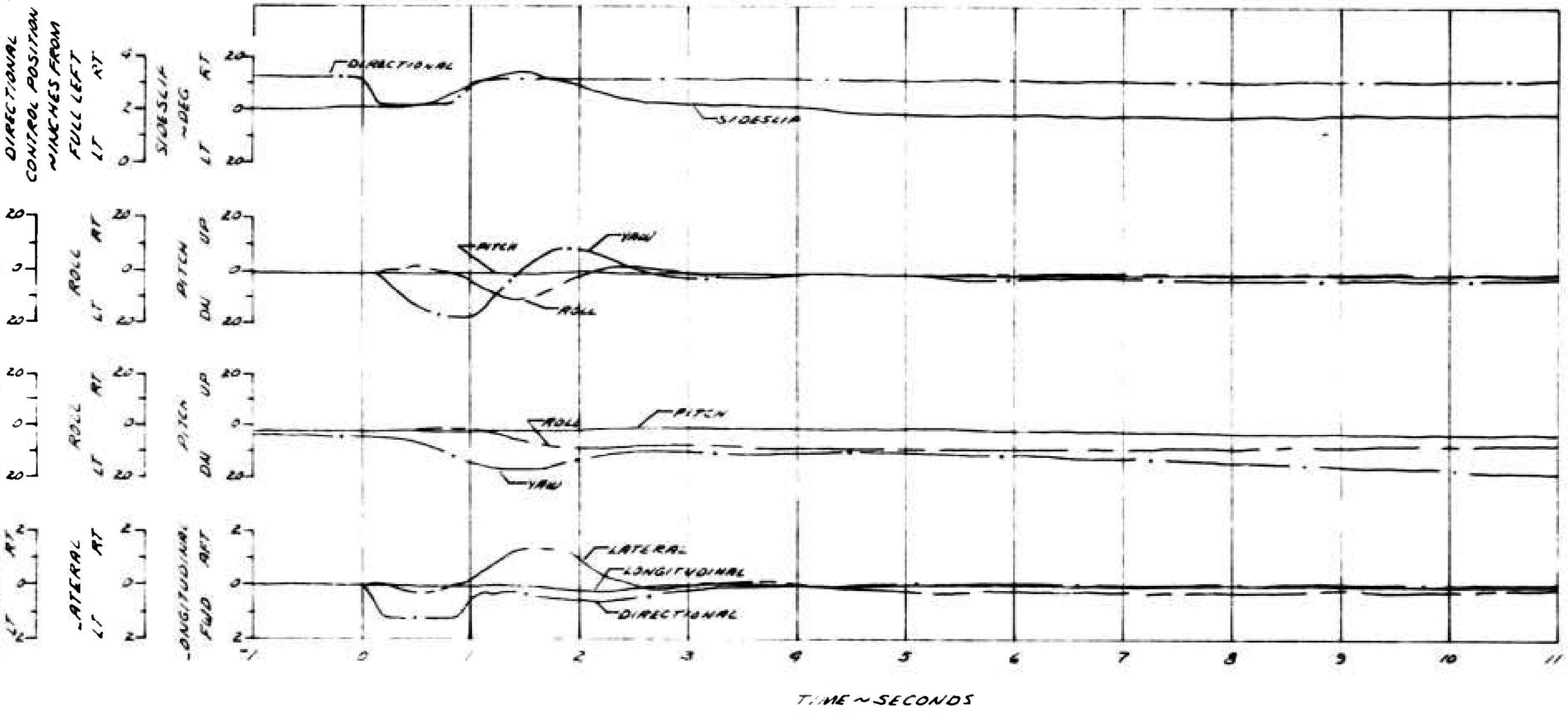


FIGURE 28

AIRCRAFT RESPONSE FOLLOWING RELEASE FROM SIDESLIP

AH-1G USA S/N 71-20985

| FLIGHT CONDITION | GROSS WEIGHT (LB) | DENSITY ALTITUDE (FT) | OAT (°C) | CG LOCATION (IN) | ROTOR SPEED (RPM) | $C_T$ | TRIM AIRSPEED (KCAS) | CONFIGURATION |
|---|---|---|---|---|---|---|---|---|
| LEVEL | 8800 | 4760 | 26.0 | 193.5 | 323 | .005066 | 96 | HOG |

NOTE:
SCAS ON

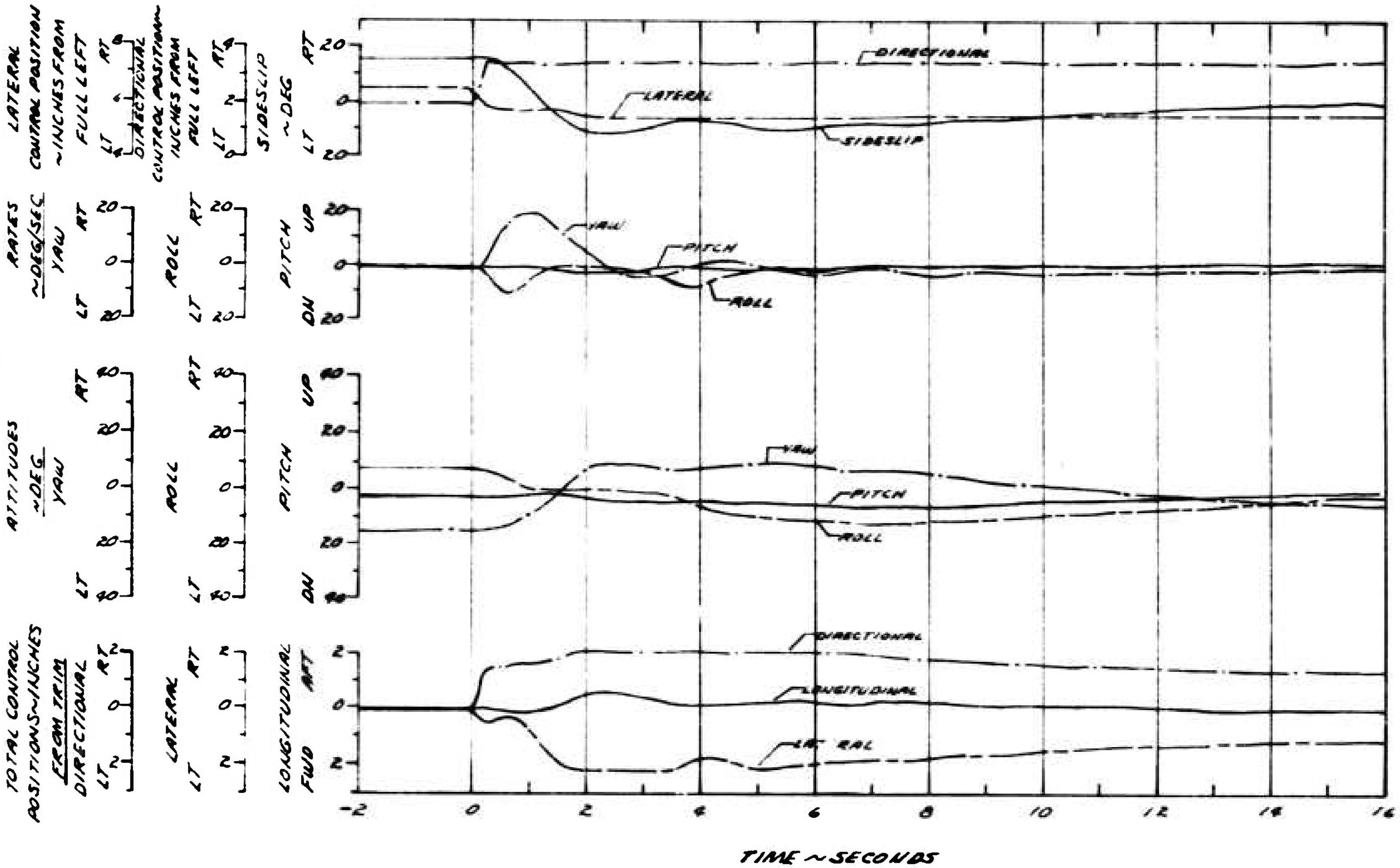


FIGURE 29

**AIRCRAFT RESPONSE FOLLOWING RELEASE FROM SIDESLIP**

AH-1G USA S/N 71-20985

| FLIGHT CONDITION | GROSS WEIGHT (LB) | DENSITY ALTITUDE (FT) | OAT (°C) | CG LOCATION (IN.) | ROTOR SPEED (RPM) | $C_T$ | TRIM AIRSPEED (KCAS) | CONFIGURATION |
|---|---|---|---|---|---|---|---|---|
| LEVEL | 8350 | 4440 | 26C | 193.4 | 319 | .004881 | 131 | H06 |

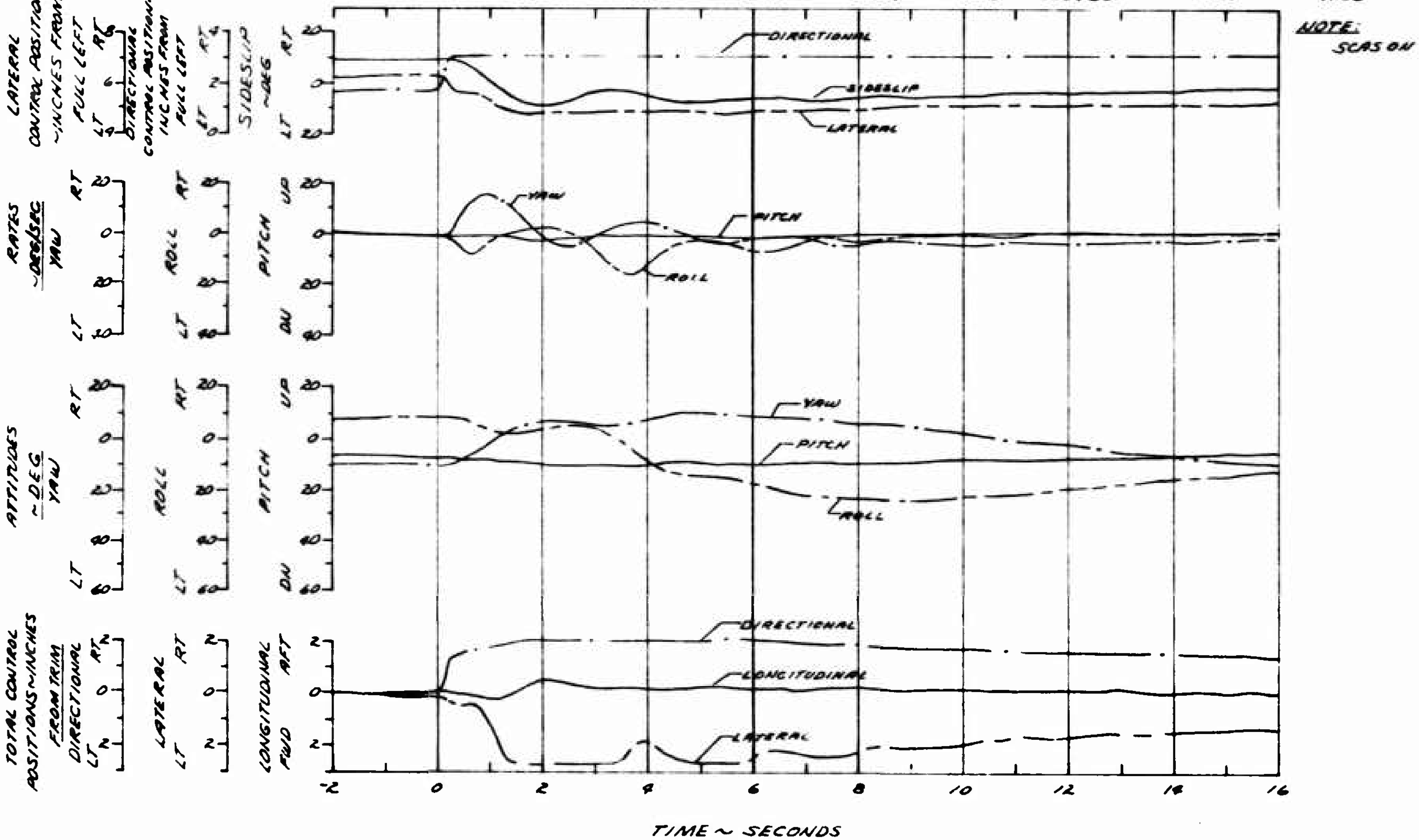


FIGURE 30

AIRCRAFT RESPONSE FOLLOWING A LEFT LATERAL PULSE

AH-1G USA S/N 71-20985

| FLIGHT CONDITION | GROSS WEIGHT (LB) | DENSITY ALTITUDE (FT) | OAT (°C) | CG LOCATION (IN) | ROTOR SPEED (RPM) | $C_T$ | TRIM AIRSPEED (KCAS) | CONFIGURATION |
|---|---|---|---|---|---|---|---|---|
| LEVEL | 8480 | 4220 | 22.0 | 199.4 | 324 | .004773 | 121 | HOG |

NOTE:
LATERAL SCAS OFF

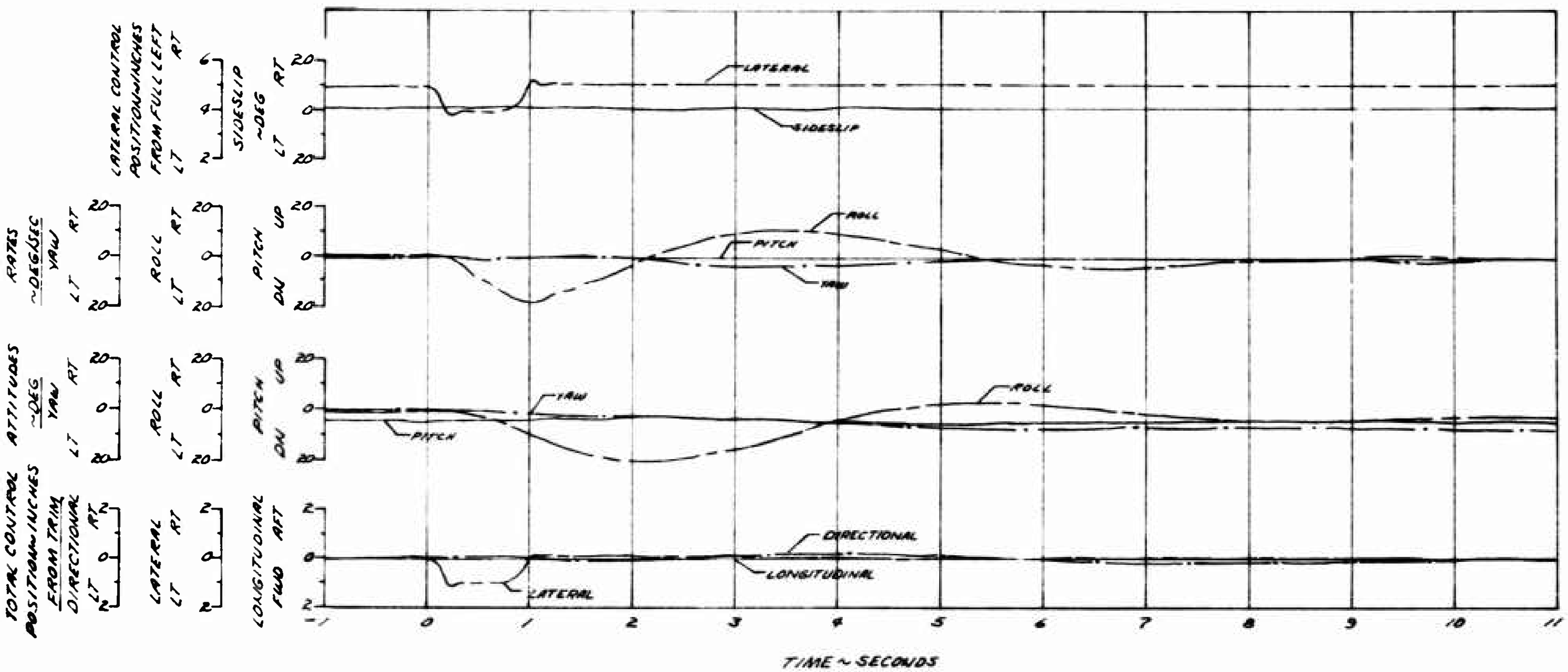


FIGURE 31

AIRCRAFT RESPONSE FOLLOWING A RIGHT DIRECTIONAL PULSE

AH-1G USA S/N 71-20985

| FLIGHT CONDITION | GROSS WEIGHT (LB) | DENSITY ALTITUDE (FT) | OAT (°C) | CG LOCATION (IN) | ROTOR SPEED (RPM) | $C_T$ | TRIM AIRSPEED (KCAS) | CONFIGURATION |
|---|---|---|---|---|---|---|---|---|
| LEVEL | 8630 | 4300 | 24.5 | 199.5 | 324 | .004993 | 93 | HOG |

NOTE:
DIRECTIONAL SCAS OFF

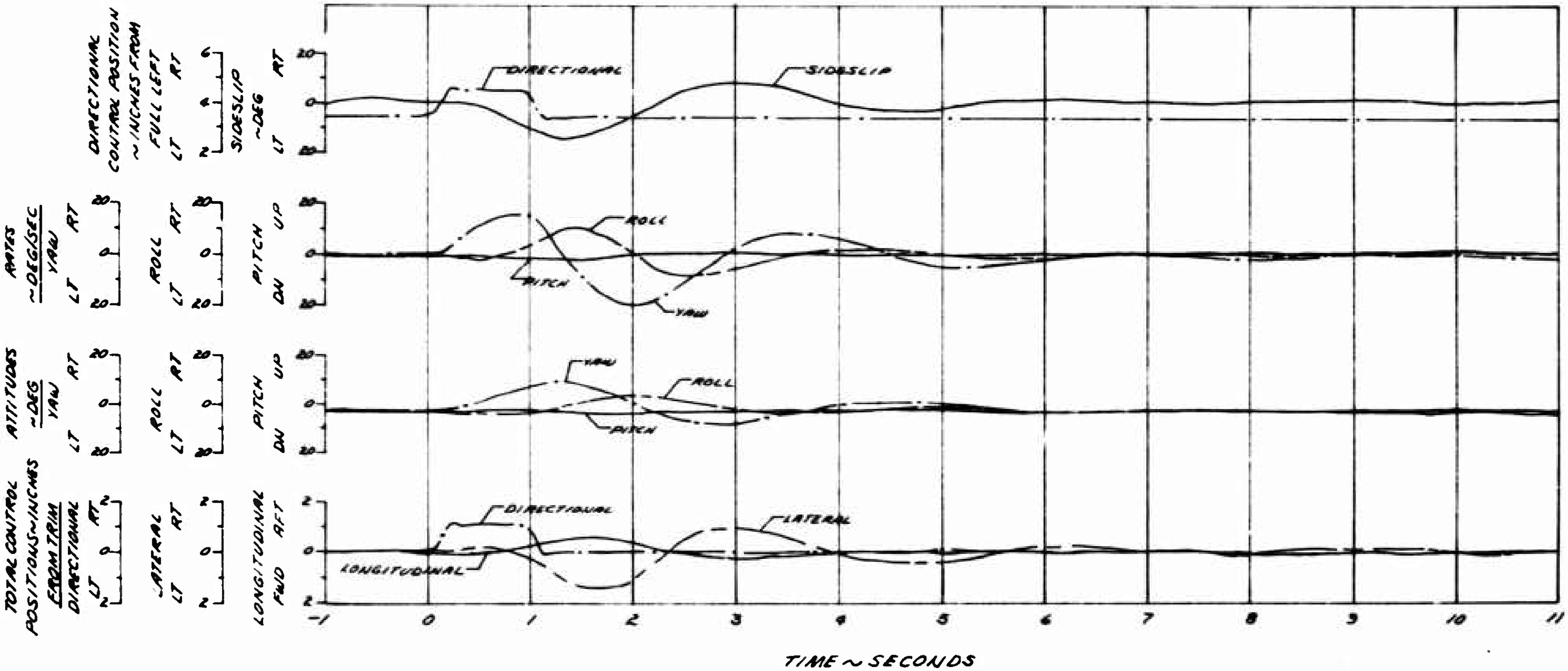


FIGURE 32

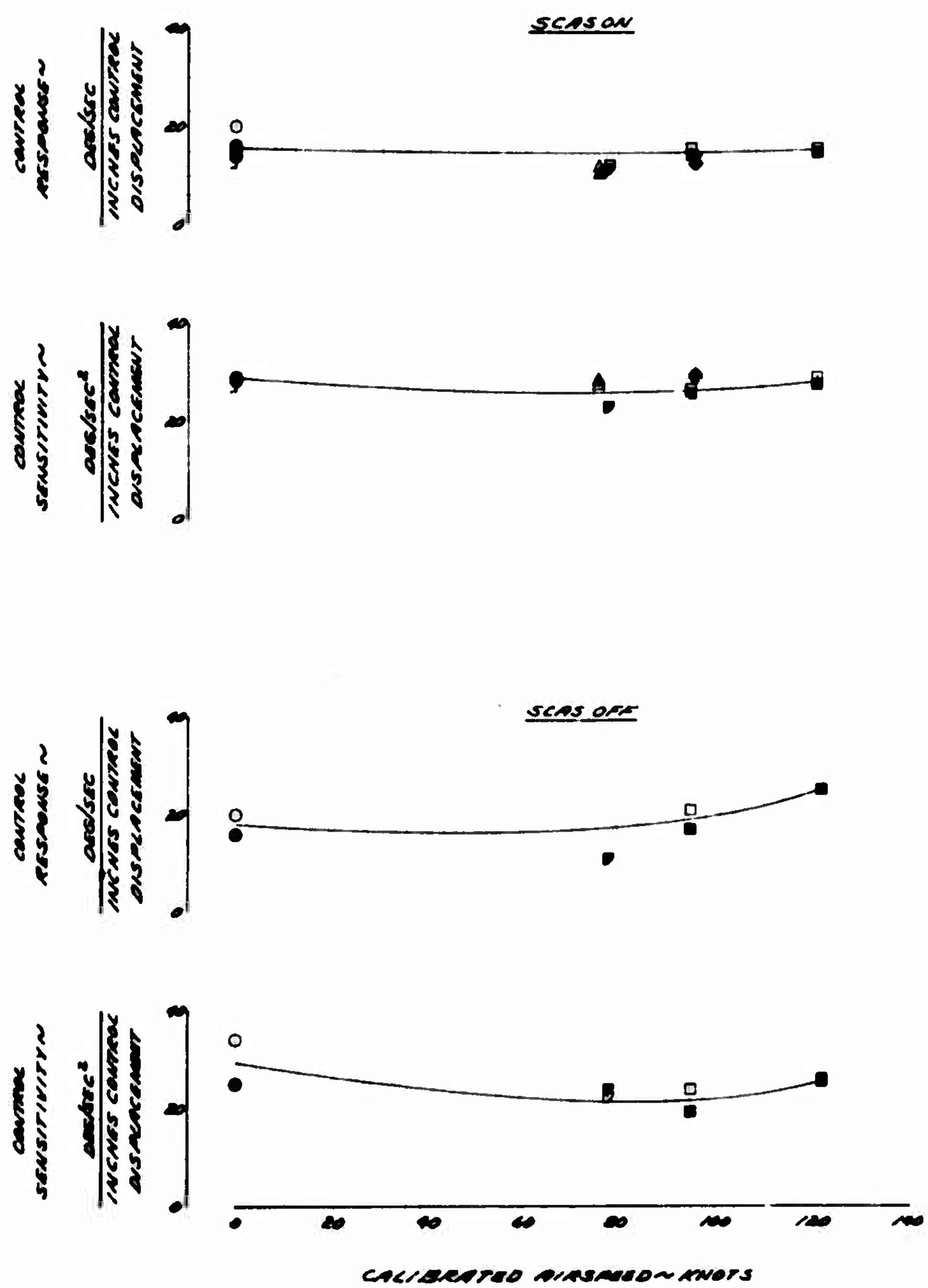
SUMMARY LATERAL CONTROL RESPONSE AND SENSITIVITY

AH-1G USA S/N 71-20985

| SYMBOL | FLIGHT CONDITION | AVG GROSS WEIGHT (LB) | AVG DENSITY ALTITUDE (FT) | AVG OAT (°C) | AVG CG LOCATION (IN) | AVG ROTOR SPEED (RPM) | AVG $C_T$ | CONFIG |
|---|---|---|---|---|---|---|---|---|
| ○ | HOVER | 8830 | 1700 | 25.0 | 133.5 | 324 | .004610 | HOG |
| ○̣ | HOVER | 7670 | 11400 | 12.5 | 133.5 | 324 | .005330 | HOG |
| □ | LEVEL | 8660 | 4800 | 26.0 | 133.5 | 323 | .004931 | HOG |
| △ | CLIMB | 8800 | 4840 | 26.0 | 133.5 | 324 | .005047 | HOG |
| ◇ | DESCENT | 8810 | 4720 | 25.5 | 133.7 | 323 | .005083 | HOG |
| ▽ | AUTO | 8780 | 4660 | 25.5 | 133.5 | 322 | .005071 | HOG |

NOTES:

1. OPEN SYMBOLS DENOTE LEFT INPUT.
2. SOLID SYMBOLS DENOTE RIGHT INPUT.
3. POINTS DERIVED FROM FIGURES 31 THROUGH 35.
4. CONTROL RESPONSE IN HOVER MEASURED AT ONE SECOND.



## FIGURE 33
## LATERAL CONTROLLABILITY
## AH-1G USA S/N 71-20985
## HOG CONFIGURATION

| SYMBOL | SCAS CONDITION | AVG GROSS WEIGHT (LB) | AVG DENSITY ALTITUDE (FT) | AVG OAT (°C) | AVG CG LOCATION (IN) | AVG ROTOR SPEED (RPM) | AVG $C_T$ | AVG TRIM AIRSPEED (KCAS) |
|---|---|---|---|---|---|---|---|---|
| ○ | ON | 7670 | 11400 | 12.5 | 199.5 | 324 | .005392 | 0 |
| □ | ON | 8810 | 1790 | 25.5 | 199.5 | 324 | .004605 | 0 |
| △ | OFF | 8890 | 1660 | 24.5 | 199.6 | 323 | .004637 | 0 |

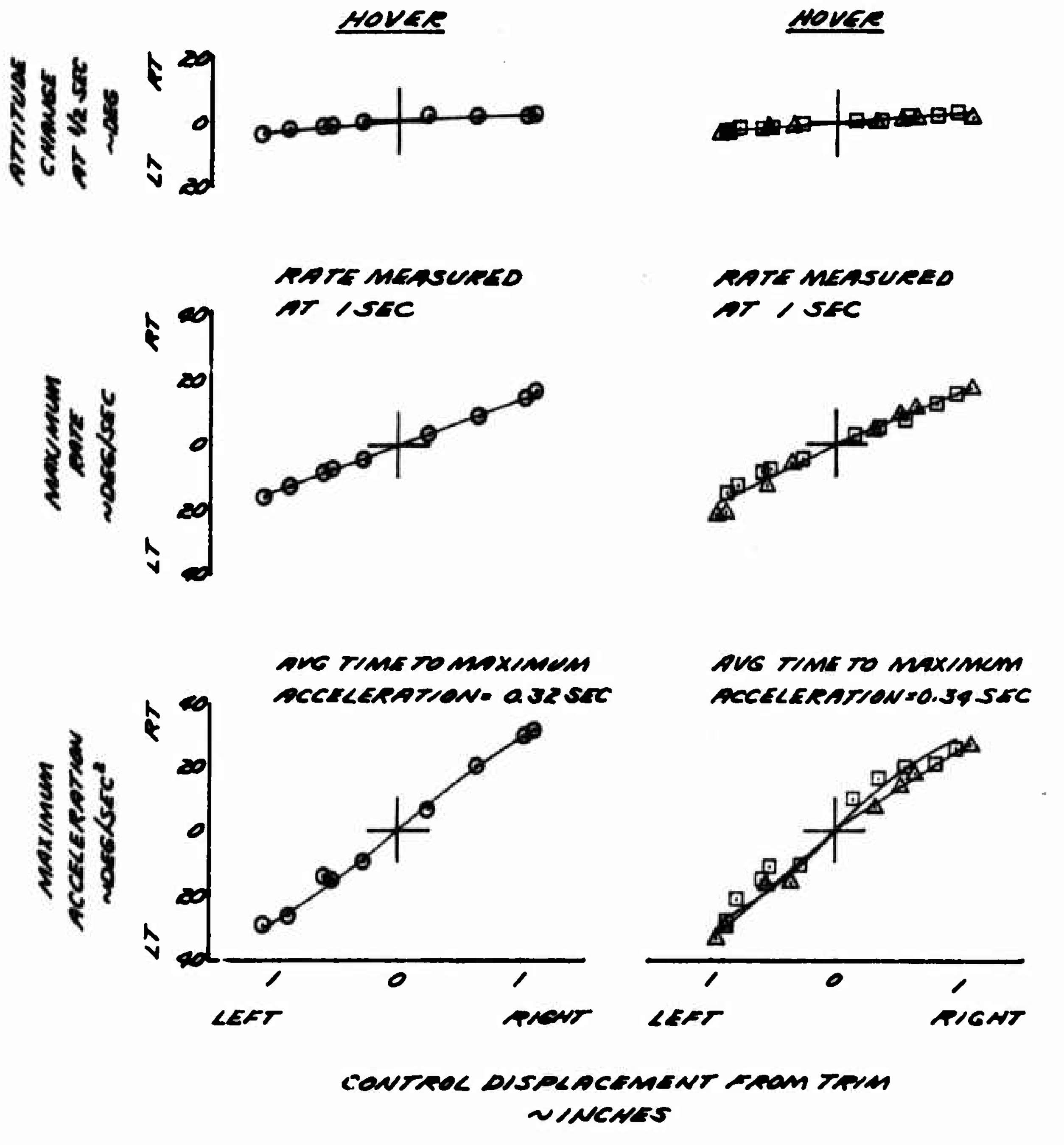


FIGURE 34

LATERAL CONTROLLABILITY

AH-1G USA S/N 71-20985

HOG CONFIGURATION

| SYMBOL | SCAS CONDITION | AVG GROSS WEIGHT (LB) | AVG DENSITY ALTITUDE (FT) | AVG OAT (°C) | AVG CG LOCATION (IN.) | AVG ROTOR SPEED (RPM) | AVG $C_T$ | AVG TRIM AIRSPEED (KCAS) |
|---|---|---|---|---|---|---|---|---|
| ○ | ON | 8780 | 4840 | 26.0 | 199.5 | 323 | .005067 | 95 |
| □ | OFF | 8820 | 4740 | 25.0 | 199.7 | 323 | .005075 | 95 |

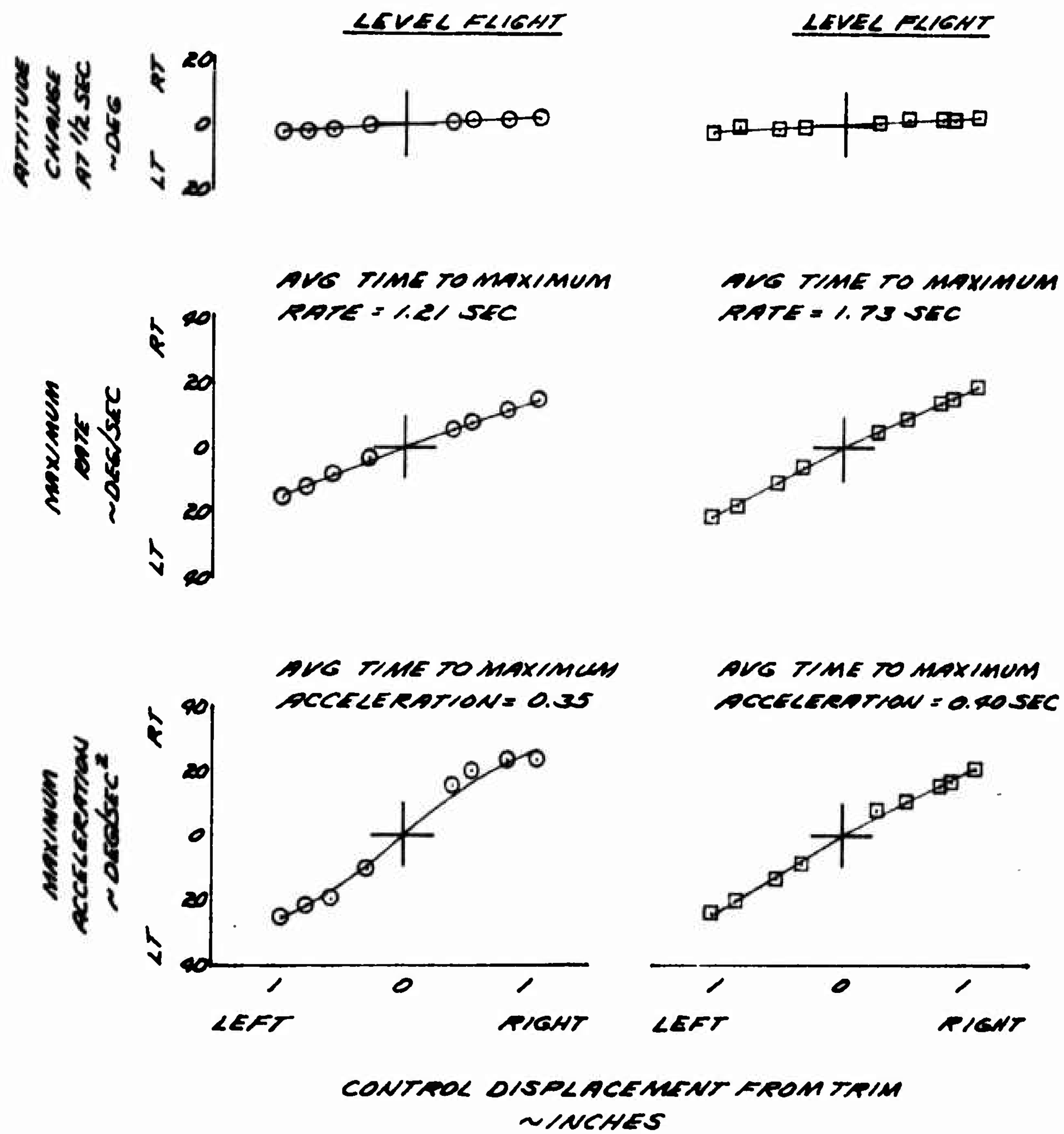


FIGURE 35
LATERAL CONTROLLABILITY
AH-1G USA S/N 71-20985
HOG COFIGURATION

| SYMBOL | SCAS CONDITION | AVG GROSS WEIGHT (LB) | AVG DENSITY ALTITUDE (FT) | AVG OAT (°C) | AVG CG LOCATION (IN.) | AVG ROTOR SPEED (RPM) | AVG $C_T$ | AVG TRIM AIRSPEED (KCAS) |
|---|---|---|---|---|---|---|---|---|
| ○ | ON | 8470 | 4740 | 25.0 | 193.4 | 323 | .004873 | 121 |
| □ | OFF | 8570 | 4900 | 28.0 | 193.5 | 323 | .004965 | 122 |

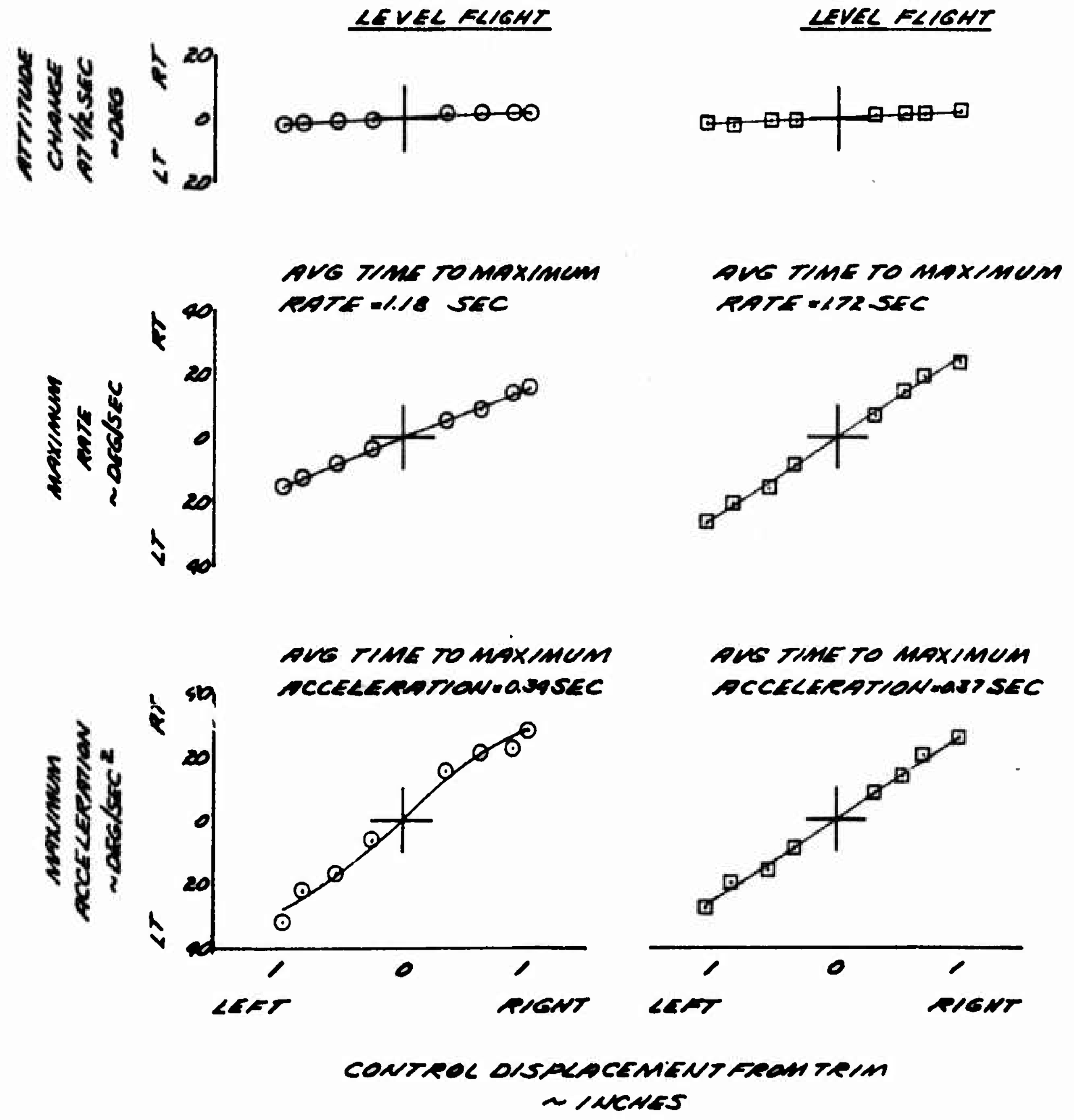


FIGURE 36

LATERAL CONTROLLABILITY

AH-1G USA S/N 71-20985

HOG CONFIGURATION

| SYMBOL | SCAS CONDITION | AVG GROSS WEIGHT (LB) | AVG DENSITY ALTITUDE (FT) | AVG OAT (°C) | AVG CG LOCATION (IN.) | AVG ROTOR SPEED (RPM) | AVG $C_T$ | TRIM AIRSPEED (KCAS) |
|---|---|---|---|---|---|---|---|---|
| ○ | ON | 8800 | 4840 | 26.0 | 199.5 | 324 | .005047 | 76 |
| □ | ON | 8840 | 4720 | 25.5 | 199.7 | 323 | .005083 | 96 |

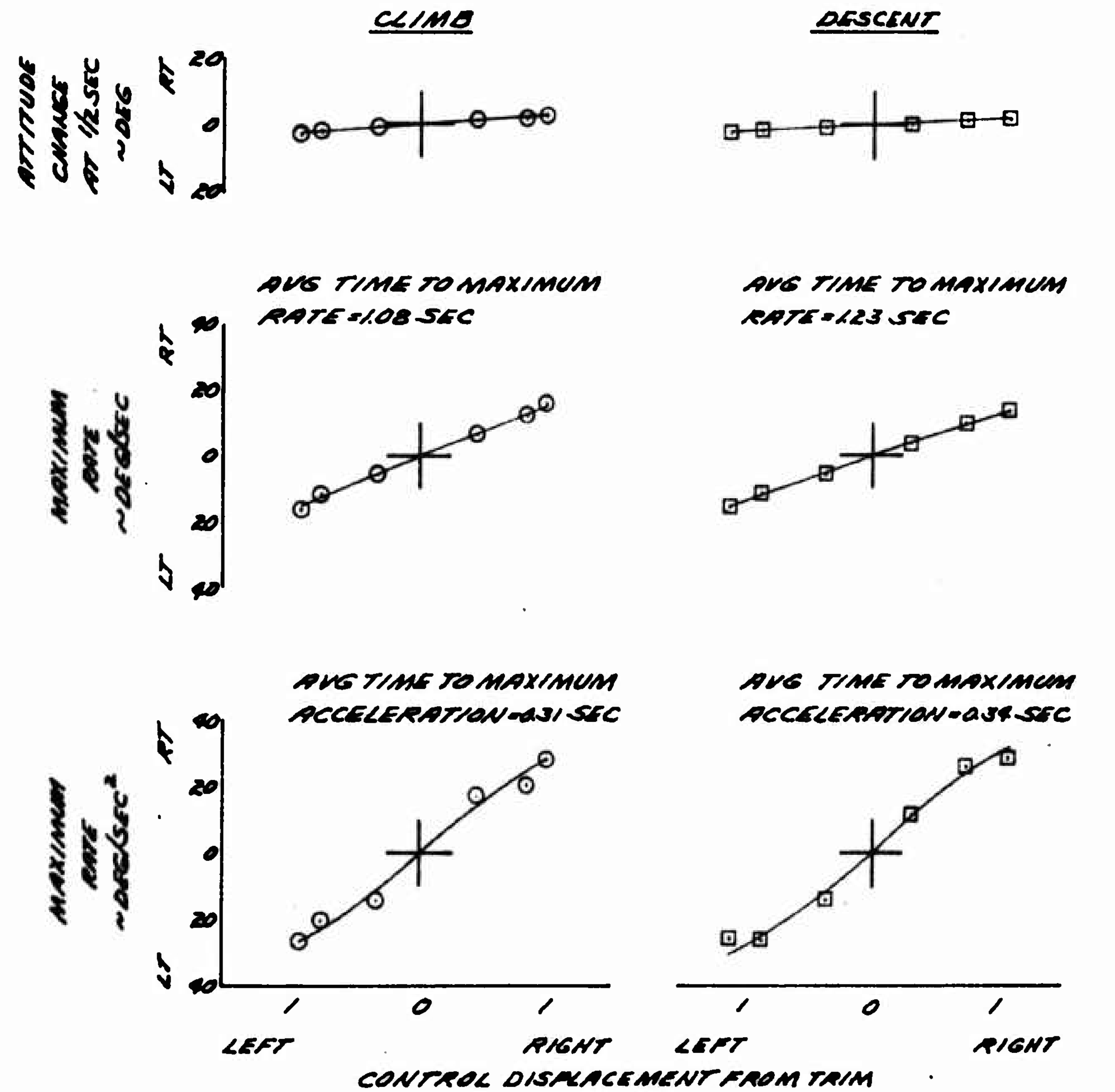


FIGURE 37

LATERAL CONTROLLABILITY

AH-1G USA S/N 71-20985

HOG CONFIGURATION

| SYMBOL | SCAS CONDITION | AVG GROSS WEIGHT (LB) | AVG DENSITY ALTITUDE (FT) | AVG OAT (°C) | AVG CG LOCATION (IN.) | AVG ROTOR SPEED (RPM) | AVG $C_T$ | AVG TRIM AIRSPEED (KCAS) |
|---|---|---|---|---|---|---|---|---|
| ○ | ON | 8730 | 4700 | 25.5 | 193.5 | 322 | .005082 | 78 |
| □ | OFF | 8760 | 4600 | 26.0 | 193.5 | 321 | .005081 | 77 |

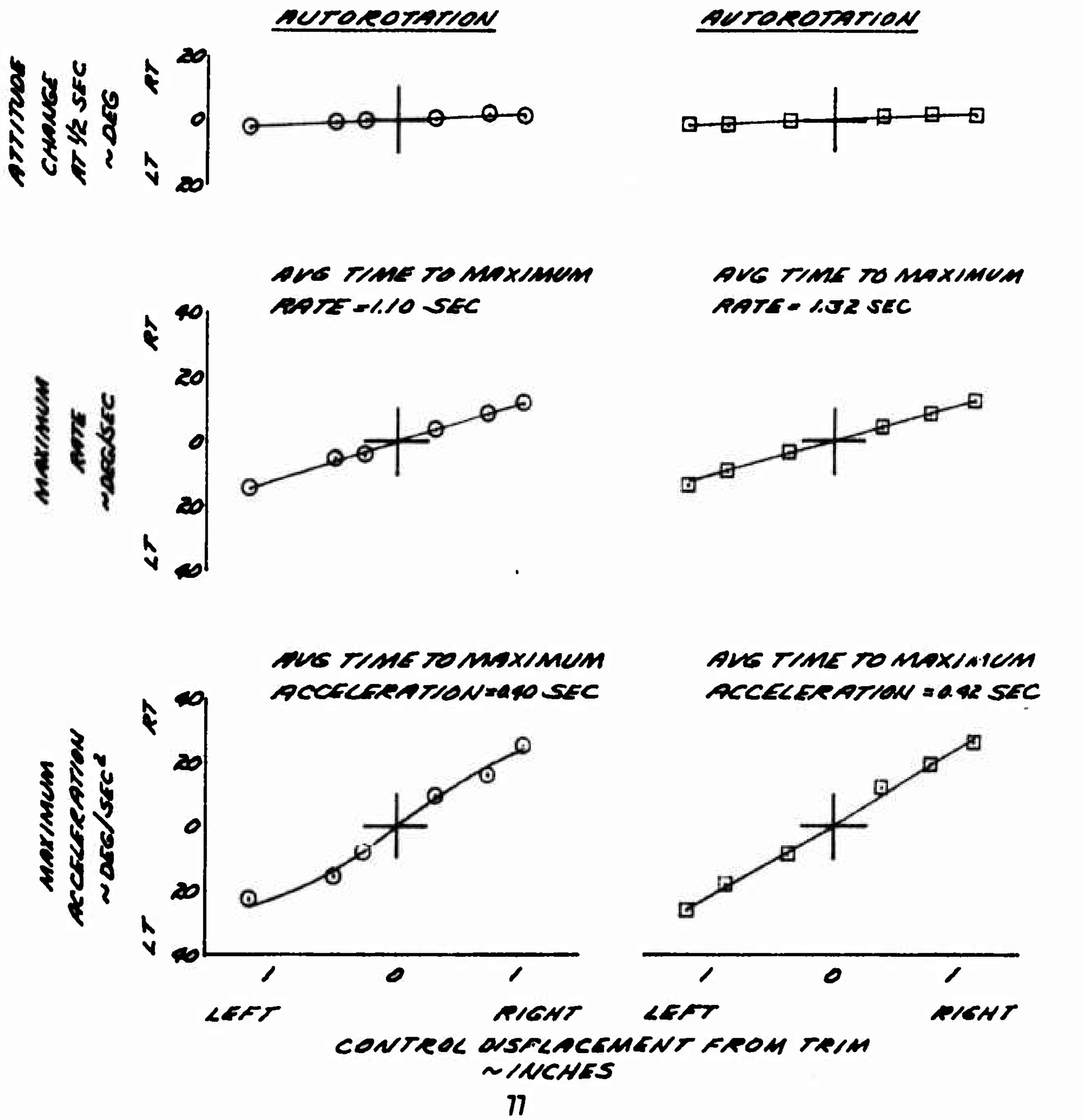


FIGURE 38

SUMMARY DIRECTIONAL CONTROL RESPONSE AND SENSITIVITY

AH-1S USA S/N 71-20985

| SYMBOL | FLIGHT CONDITION | AVG GROSS WEIGHT (LB) | AVG DENSITY ALTITUDE (FT) | AVG OAT (°C) | AVG CG LOCATION (IN.) | AVG ROTOR SPEED (RPM) | AVG $C_T$ | CONFIG |
|---|---|---|---|---|---|---|---|---|
| ○ | HOVER | 8700 | 1720 | 26.0 | 193.5 | 323 | .004875 | HOG |
| ♀ | HOVER | 7320 | 11220 | 10.6 | 199.6 | 323 | .005569 | HOG |
| □ | LEVEL | 8570 | 4860 | 26.5 | 193.5 | 324 | .004918 | HOG |
| △ | CLIMB | 8600 | 4660 | 25.5 | 193.6 | 323 | .004936 | HOG |
| ◇ | DESCENT | 8700 | 4700 | 25.6 | 193.6 | 324 | .004382 | HOG |
| ▷ | AUTO | 8560 | 4760 | 25.6 | 193.6 | 323 | .004328 | HOG |

NOTES:

1. OPEN SYMOLS DENOTE LEFT INPUT.
2. SOLID SYMBOL DENOTE RIGHT INPUT.
3. POINTS DERIVED FROM FIGURES 37 THROUGH 41.
4. CONTROL RESPONSE IN HOVER MEASURED AT ONE SECOND.

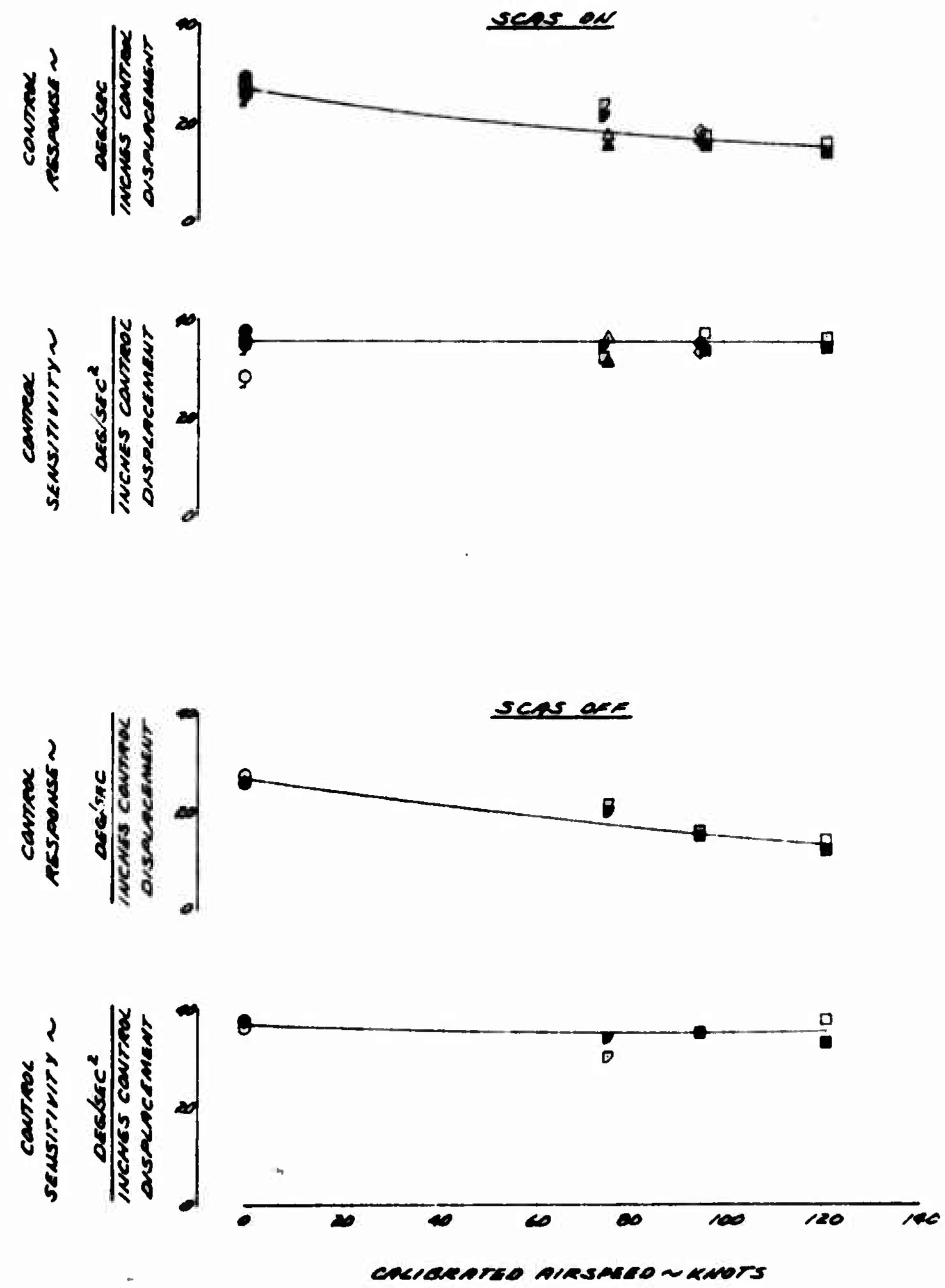


FIGURE 39

DIRECTIONAL CONTROLLABILITY

AH-1G USA S/N 71-20985

HOG CONFIGURATION

| SYMBOL | SCAS CONDITION | AVG GROSS WEIGHT (LB) | AVG DENSITY ALTITUDE (FT) | AVG OAT (°C) | AVG CG LOCATION (IN.) | AVG ROTOR SPEED (RPM) | AVG $C_T$ | AVG TRIM AIRSPEED (KCAS) |
|---|---|---|---|---|---|---|---|---|
| ○ | ON | 7320 | 11220 | 10.5 | 193.6 | 323 | .005569 | 0 |
| □ | ON | 8590 | 1800 | 26.0 | 193.5 | 323 | .004527 | 0 |
| △ | OFF | 8820 | 1640 | 24.0 | 193.5 | 323 | .004625 | 0 |

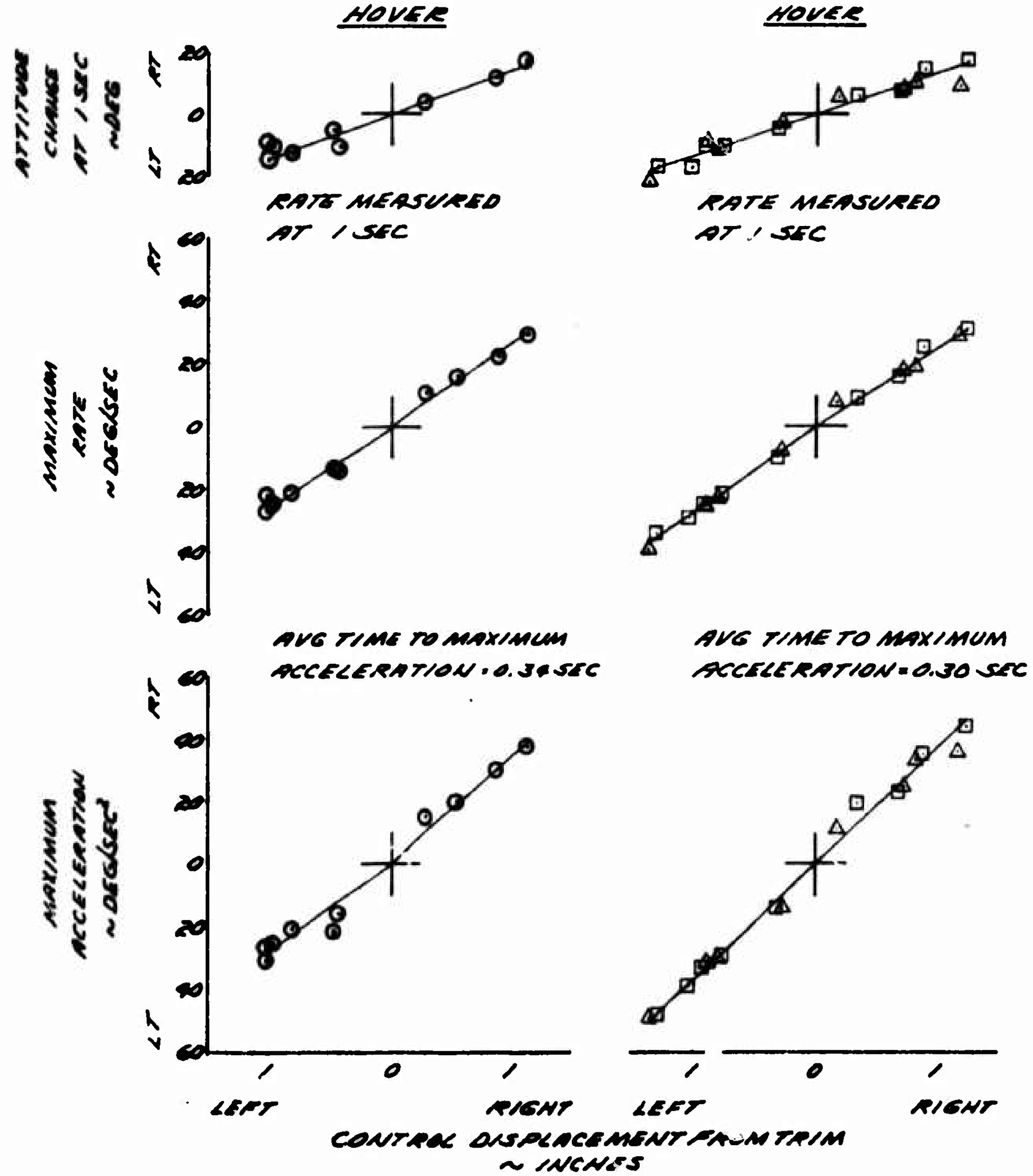


FIGURE 40
DIRECTIONAL CONTROLLABILITY
AH-1G USA S/N 71-20985
HOG CONFIGURATION

| SYMBOL | SCAS CONDITION | AVG GROSS WEIGHT (LB) | AVG DENSITY ALTITUDE (FT) | AVG OAT (°C) | AVG CG LOCATION (IN.) | AVG ROTOR SPEED (RPM) | AVG $C_T$ | AVG TRIM AIRSPEED (KCAS) |
|---|---|---|---|---|---|---|---|---|
| ○ | ON | 8670 | 4780 | 25.0 | 199.5 | 323 | .004994 | 96 |
| □ | OFF | 8680 | 4820 | 25.0 | 199.6 | 324 | .004976 | 95 |

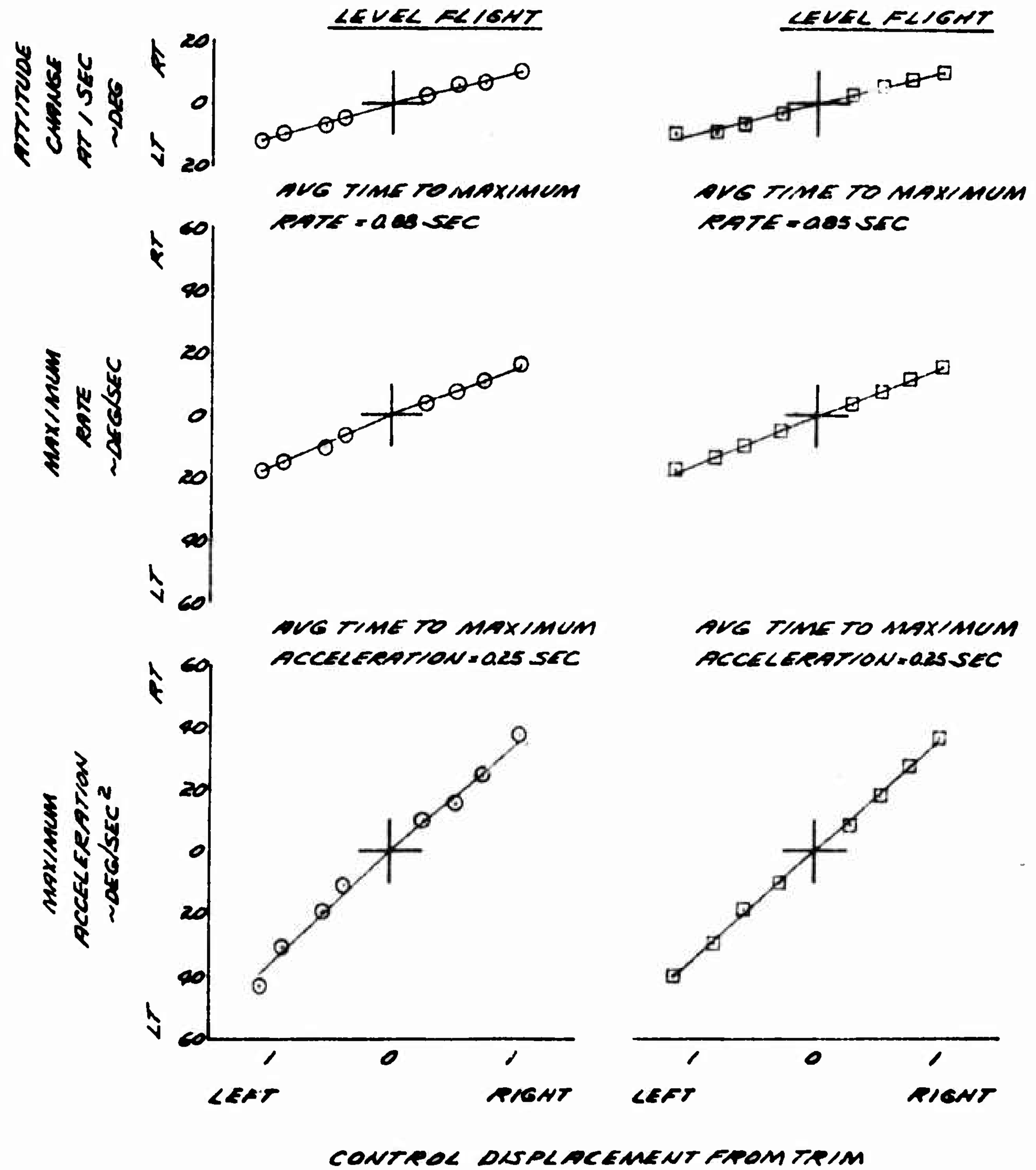


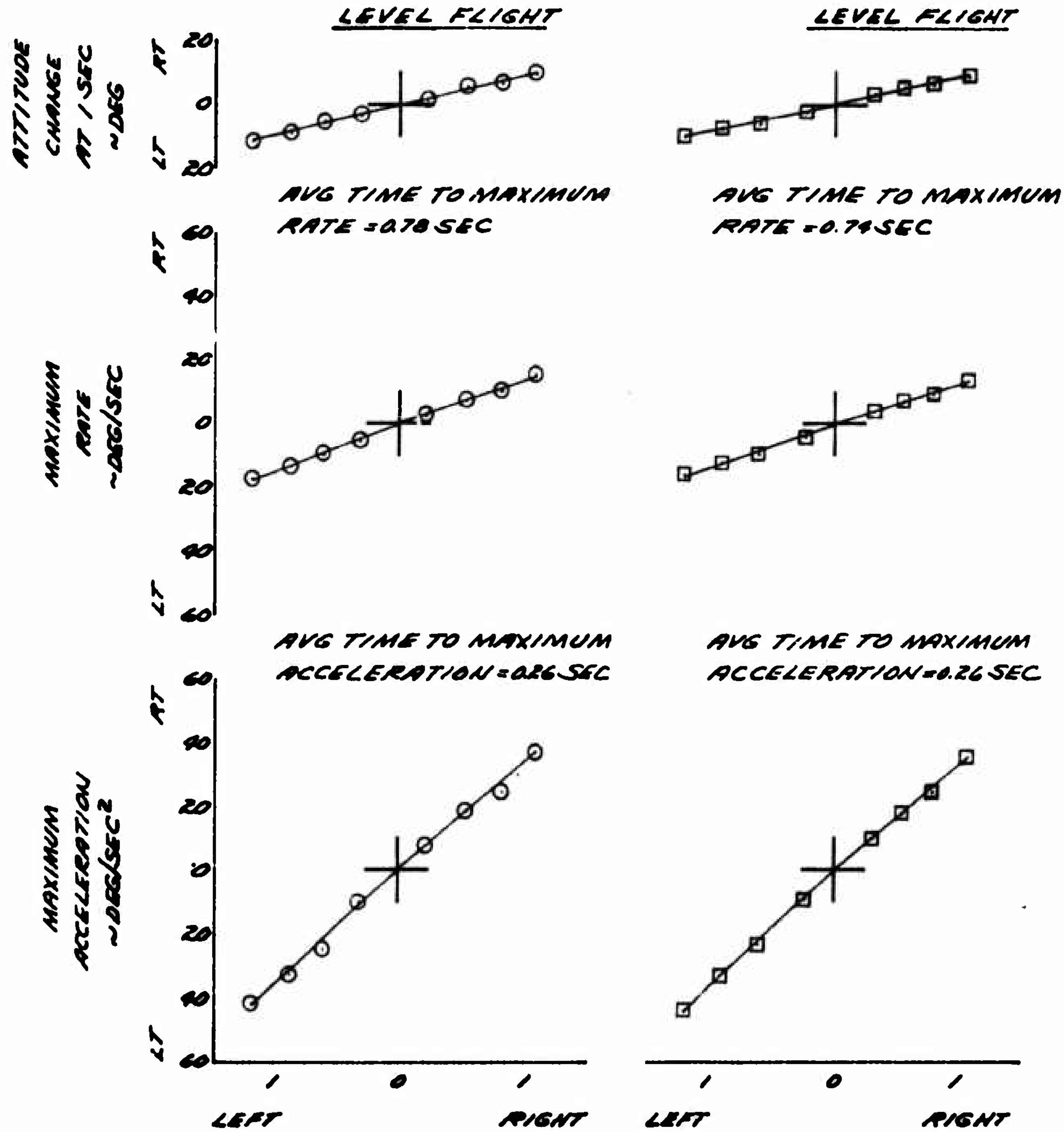
FIGURE 41

DIRECTIONAL CONTROLLABILITY

AH-1G USA S/N 71-20985

HOG CONFIGURATION

| SYMBOL | SCAS CONDITION | AVG GROSS WEIGHT (LB) | AVG DENSITY ALTITUDE (FT) | AVG OAT (°C) | AVG CG LOCATION (IN.) | AVG ROTOR SPEED (RPM) | AVG $C_T$ | AVG TRIM AIRSPEED (KCAS) |
|---|---|---|---|---|---|---|---|---|
| ○ | ON | 8510 | 4980 | 27.5 | 199.4 | 324 | .004901 | 121 |
| □ | OFF | 8410 | 4860 | 27.5 | 199.4 | 323 | .004856 | 121 |




CONTROL DISPLACEMENT FROM TRIM
~ INCHES

FIGURE 42

DIRECTIONAL CONTROLLABILITY

AH-1S USA S/N 71-20985

HOG CONFIGURATION

| SYMBOL | SCAS CONDITION | AVG GROSS WEIGHT (LB) | AVG DENSITY ALTITUDE (FT) | AVG OAT (°C) | AVG CG LOCATION (IN.) | AVG ROTOR SPEED (RPM) | AVG $C_T$ | AVG TRIM AIRSPEED (KCAS) |
|---|---|---|---|---|---|---|---|---|
| ○ | ON | 8600 | 4660 | 25.5 | 199.5 | 323 | .004906 | 75 |
| □ | ON | 8700 | 4780 | 25.5 | 199.6 | 324 | .004980 | 95 |

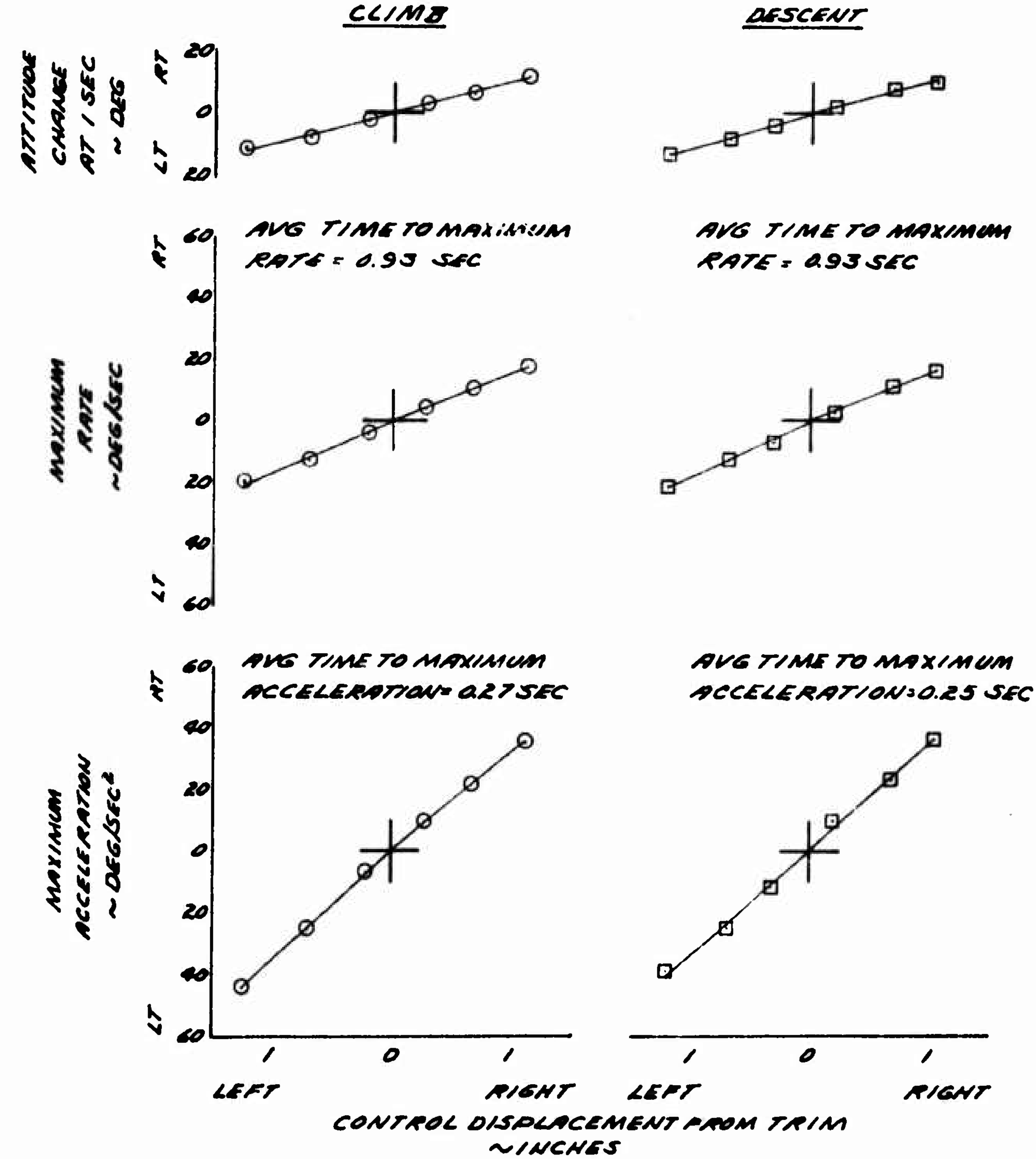


FIGURE 43
DIRECTIONAL CONTROLLABILITY
AH-1G USA S/N 71-20985
HOG CONFIGURATION

| SYMBOL | SCAS CONDITION | AVG GROSS WEIGHT (LB) | AVG DENSITY ALTITUDE (FT) | AVG OAT (°C) | AVG CG LOCATION (IN.) | AVG ROTOR SPEED (RPM) | AVG $C_T$ | AVG TRIM AIRSPEED (KCAS) |
|---|---|---|---|---|---|---|---|---|
| ○ | ON | 8590 | 4820 | 25.5 | 199.5 | 322 | .004987 | 74 |
| □ | OFF | 8530 | 4700 | 25.5 | 199.5 | 323 | .004902 | 75 |

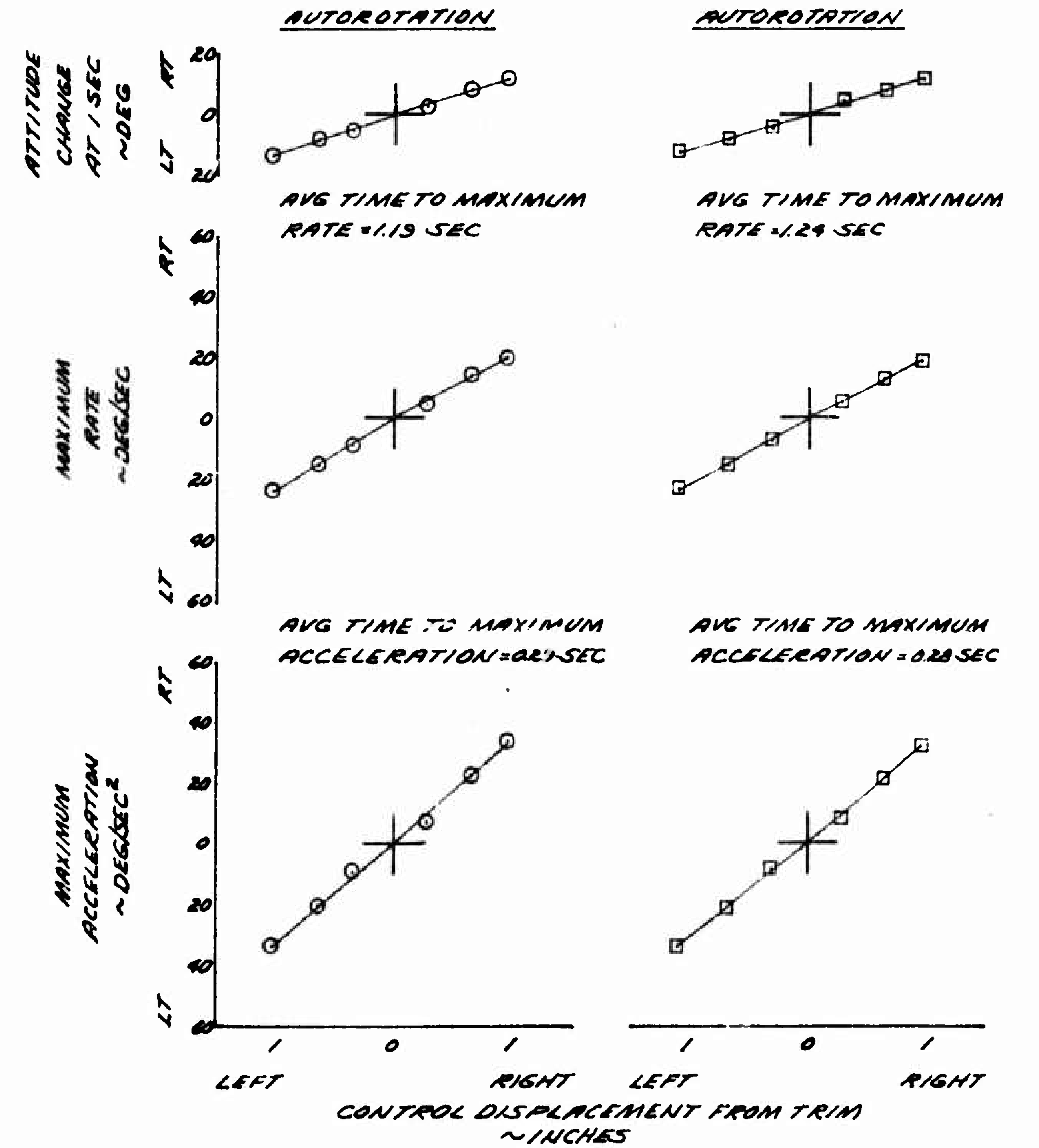


FIGURE 44

SUMMARY OF HOVER TURN ARRESTMENTS

AH-1G USA S/N 71-20986

| SYMBOL | AVG GROSS WEIGHT (LB) | AVG DENSITY ALTITUDE (FT) | AVG OAT (°C) | AVG CG LOCATION (IN.) | AVG ROTOR SPEED (RPM) | AVG $C_T$ | CONFIG |
|---|---|---|---|---|---|---|---|
| ○ | 9200 | 2580 | 31.0 | 195.1 | 324 | .004930 | HOG |
| □ | 8170 | 10800 | 9.0 | 200.2 | 325 | .005599 | HOG |

NOTES:

1. DELTA TAIL ROTOR (TR) SHAFT HORSEPOWER EQUALS PEAK TR SHAFT HORSEPOWER DURING ARRESTMENT MINUS TR SHAFT HORSEPOWER REQUIRED FOR STEADY RATE TURN.
2. LESS PEDAL TRAVEL AVAILABLE FOR ARRESTMENTS AT HIGH ALTITUDE DUE TO INCREASED TR SHAFT HORSEPOWER REQUIREMENT FOR STEADY RATE TURN.

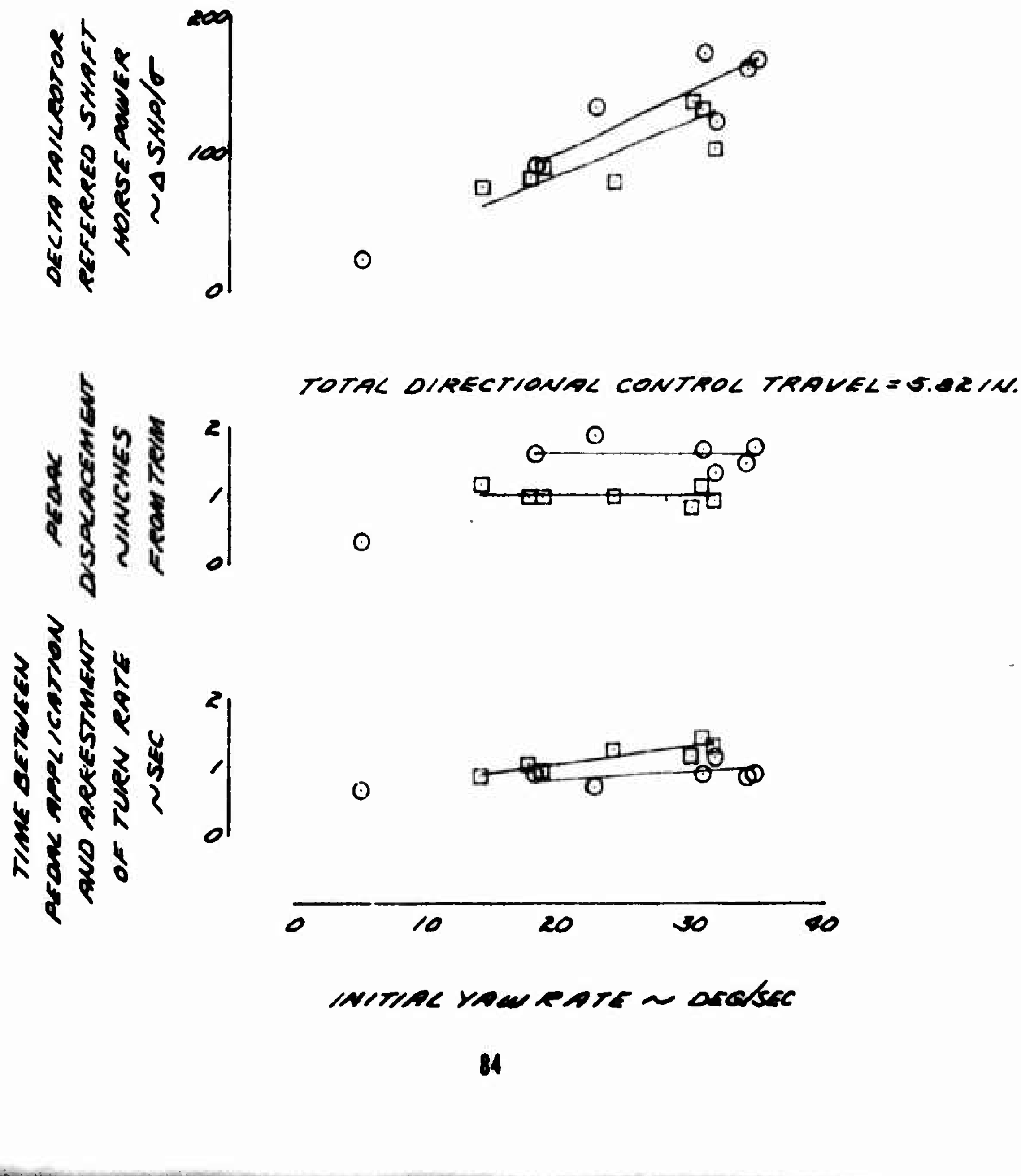


FIGURE 45
TURN ARRESTMENT IN HOVER
AH-1G USA S/N 71-20985

| GROSS WEIGHT (LB) | DENSITY ALTITUDE (FT) | OAT (°C) | CG LOCATION (IN.) | ROTOR SPEED (RPM) | $C_T$ | CONFIG |
|---|---|---|---|---|---|---|
| 9130 | 2600 | 31.0 | 195.1 | 323 | .004837 | HOG |

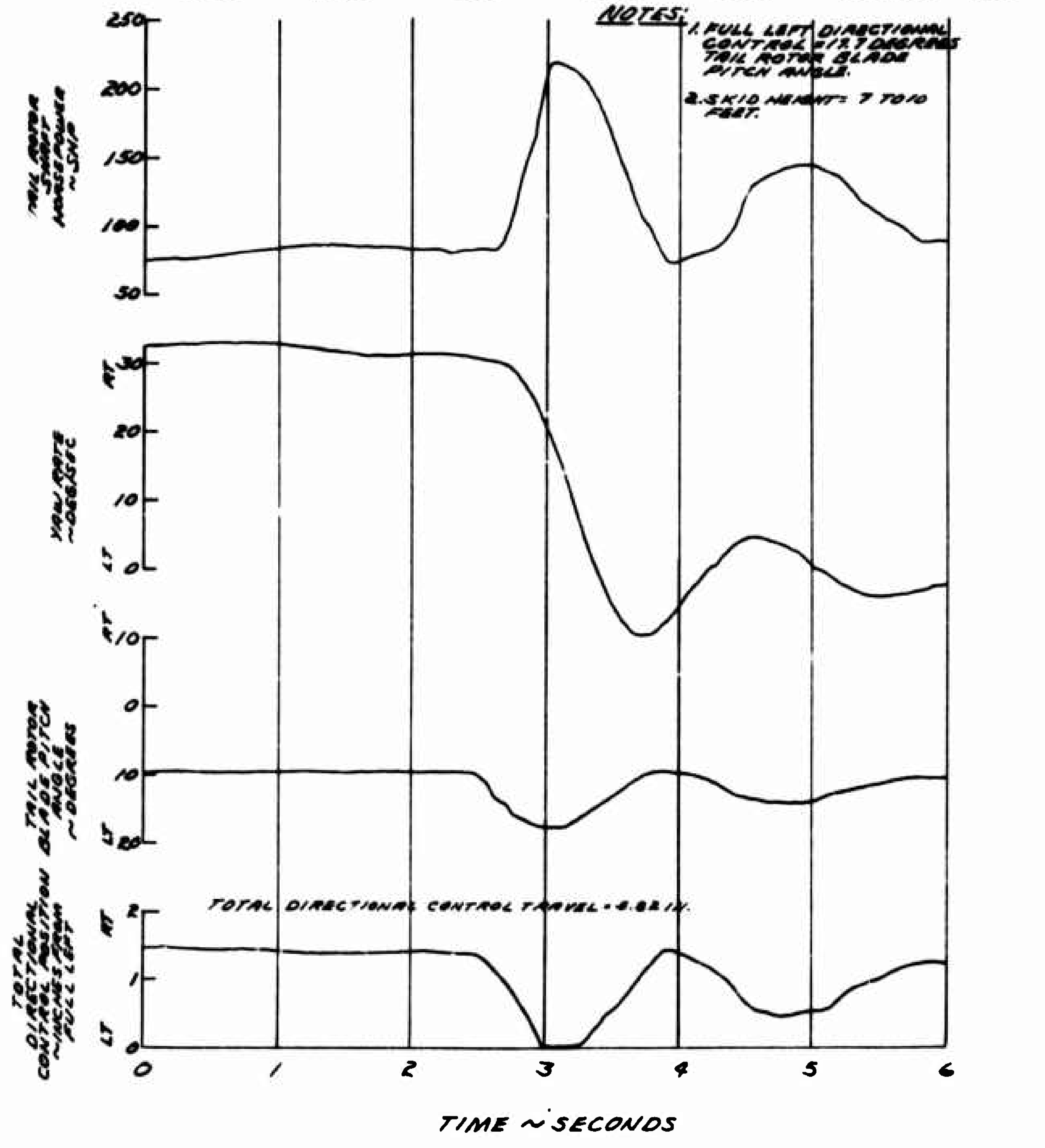


FIGURE 46
TURN ARRESTMENT IN HOVER
AH-1G USA S/N 71-20985

| GROSS WEIGHT (LB) | DENSITY ALTITUDE (FT) | OAT (°C) | CG LOCATION (IN.) | ROTOR SPEED (RPM) | $C_T$ | CONFIG |
|---|---|---|---|---|---|---|
| 8190 | 10760 | 8.5 | 200.2 | 326 | .005571 | HOG |

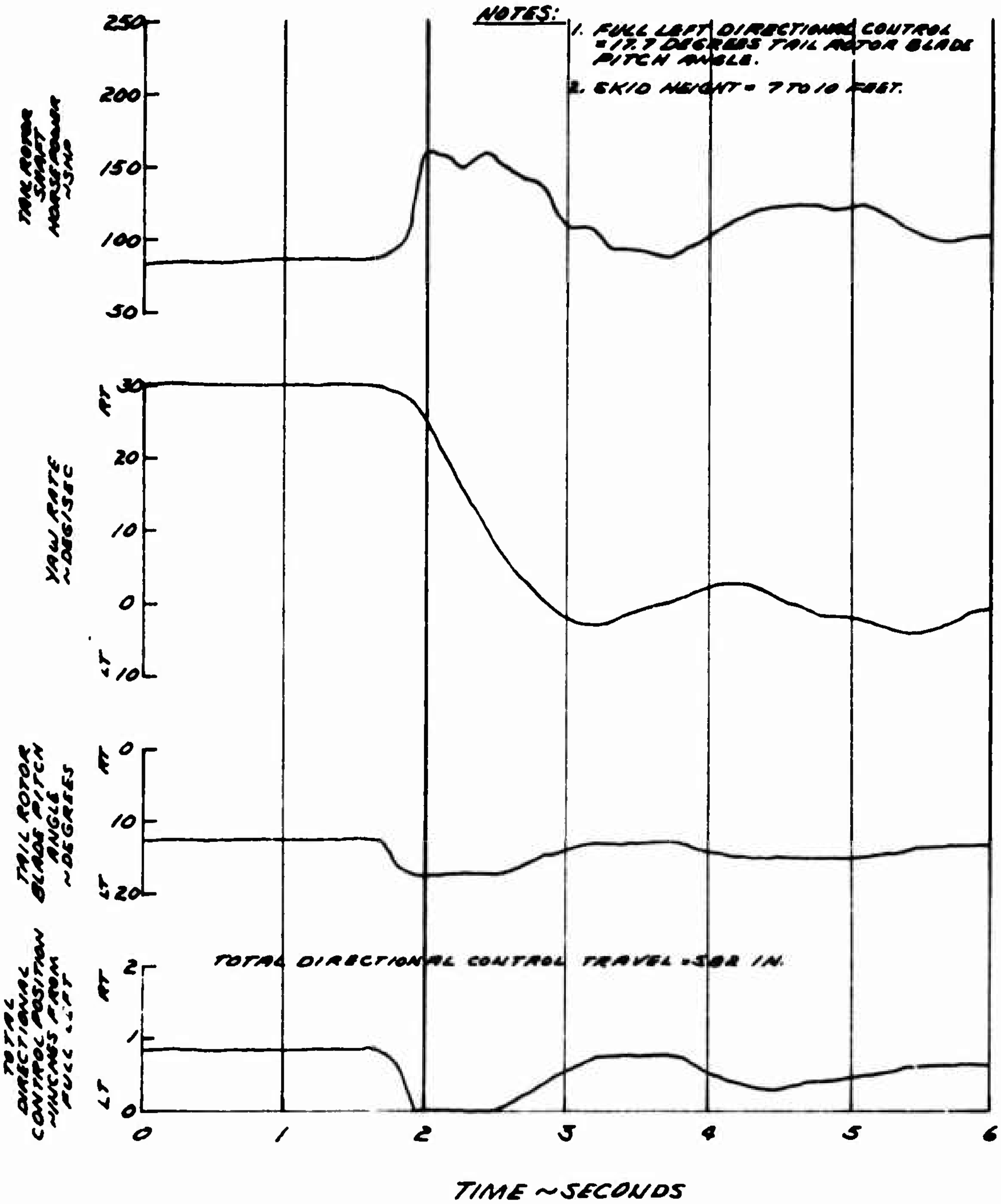


FIGURE 43

HOVERING IN WIND CAPABILITY FOR A TEN PERCENT DIRECTIONAL CONTROL MARGIN

AH-1G USA S/N 71-20985

HOG CONFIGURATION

NOTES:

1. LONGITUDINAL CENTER OF GRAVITY = 194.9 IN.
2. SKID HEIGHT = 7 TO 10 FEET.
3. WIND VELOCITY DEPICTS MOST CRITICAL WIND AZIMUTH.
4. FULL LEFT DIRECTIONAL CONTROL = 17.7 DEGREES TAIL ROTOR BLADE PITCH ANGLE.
5. POINTS OBTAINED FROM FIGURES 47 THROUGH 67.

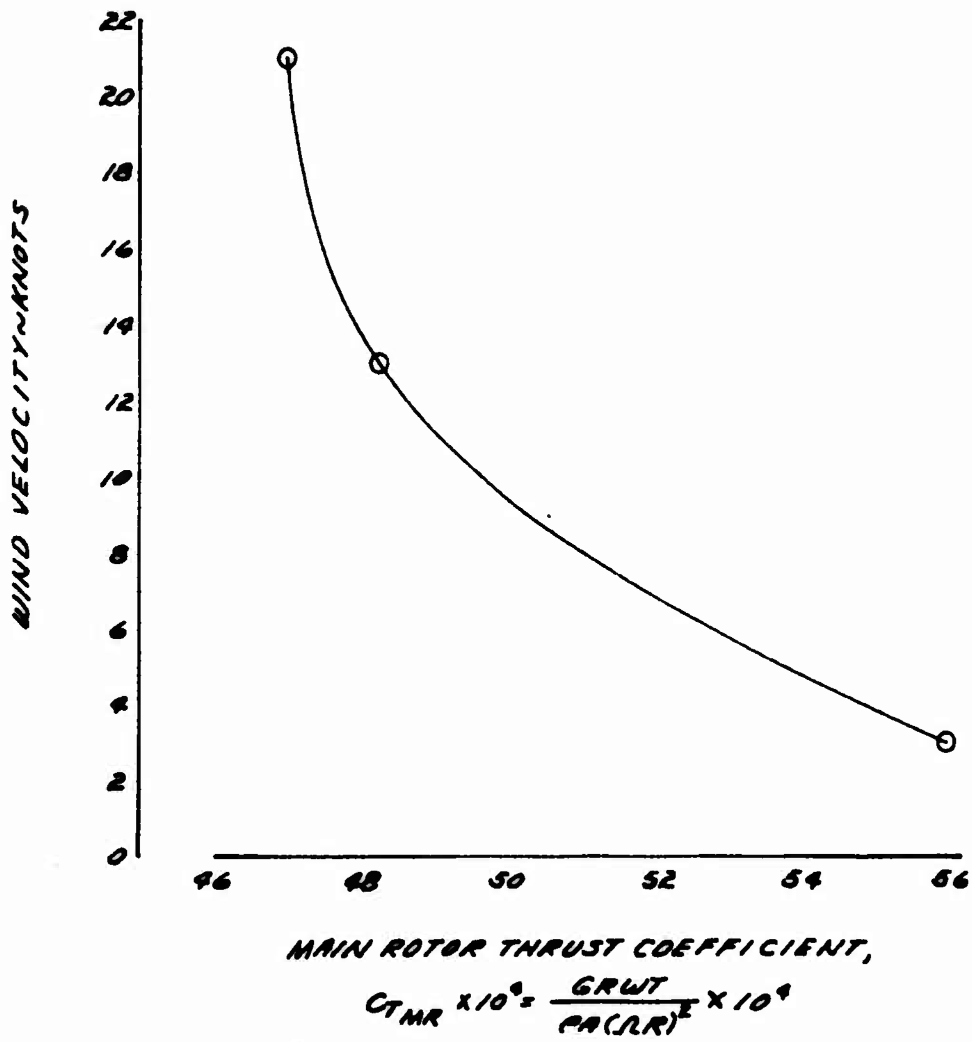
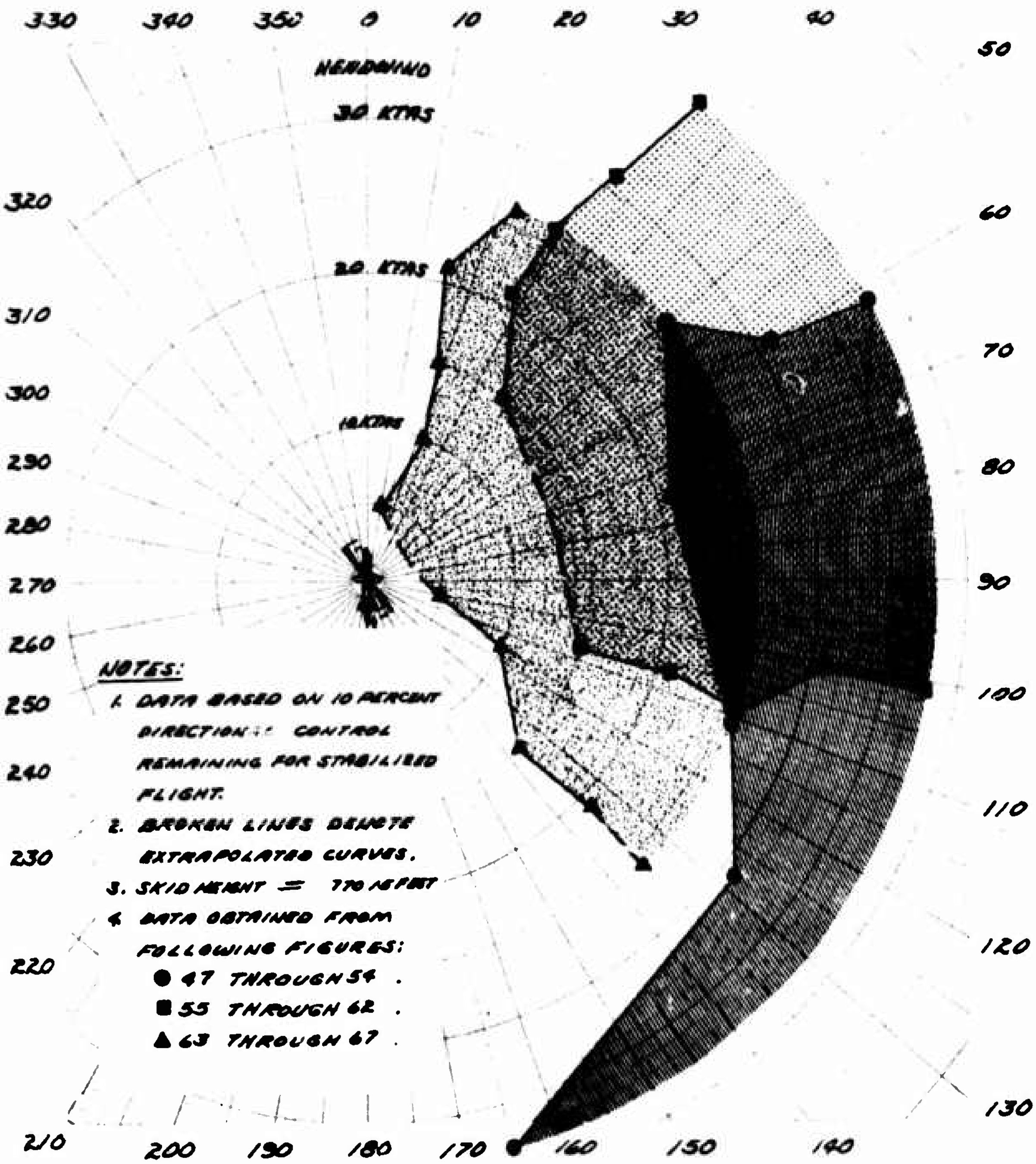


FIGURE 48

**SUMMARY TRANSLATIONAL FLIGHT**
**DIRECTIONAL CONTROL MARGIN**

AH-1G USA S/N 71-20985

| SYMBOL | SHADING | AVG GROSS WEIGHT (LB) | AVG DENSITY ALTITUDE (FT) | AVG OAT (°C) | AVG CG LOCATION (IN.) | AVG ROTOR SPEED (RPM) | AVG $C_T$ |
|---|---|---|---|---|---|---|---|
| ● | | 8960 | 2040 | 28.0 | 194.9 | 325 | .004697 |
| ■ | | 8340 | 5360 | 18.5 | 194.9 | 325 | .004840 |
| ▲ | | 8070 | 10940 | 9.5 | 194.9 | 324 | .005591 |




NOTES:

1. DATA BASED ON 10 PERCENT DIRECTIONAL CONTROL REMAINING FOR STABILIZED FLIGHT.
2. BROKEN LINES DENOTE EXTRAPOLATED CURVES.
3. SKID HEIGHT = 770 AS FEET
4. DATA OBTAINED FROM FOLLOWING FIGURES:
   - ● 47 THROUGH 54 .
   - ■ 55 THROUGH 62 .
   - ▲ 63 THROUGH 67 .

FIGURE 49

**DIRECTIONAL CONTROL AT VARIOUS RELATIVE WIND AZIMUTHS**

AH-1G USA S/N 71-20985

| AVG GROSS WEIGHT (LB) | AVG DENSITY ALTITUDE (FT) | AVG OAT (°C) | AVG CG LOCATION (IN.) | AVG ROTOR SPEED (RPM) | AVG $C_T$ | AVG TRUE AIRSPEED (KTAS) | CONFIG |
|---|---|---|---|---|---|---|---|
| 8970 | 2060 | 28.0 | 194.9 | 324 | .004731 | 5 | HOG |

NOTES:

1. TRUE AIRSPEED IS THE VECTORIAL SUM OF GROUND SPEED AND WIND VELOCITY.
2. GROUND SPEED DETERMINED WITH CALIBRATED PACE VEHICLE.
3. FULL LEFT DIRECTIONAL CONTROL = 17.7 DEGREES TAIL ROTOR BLADE PITCH ANGLE.
4. FULL RIGHT DIRECTIONAL CONTROL = -10.3 DEGREES TAIL ROTOR BLADE PITCH ANGLE.
5. WIND LESS THAN 3 KNOTS.

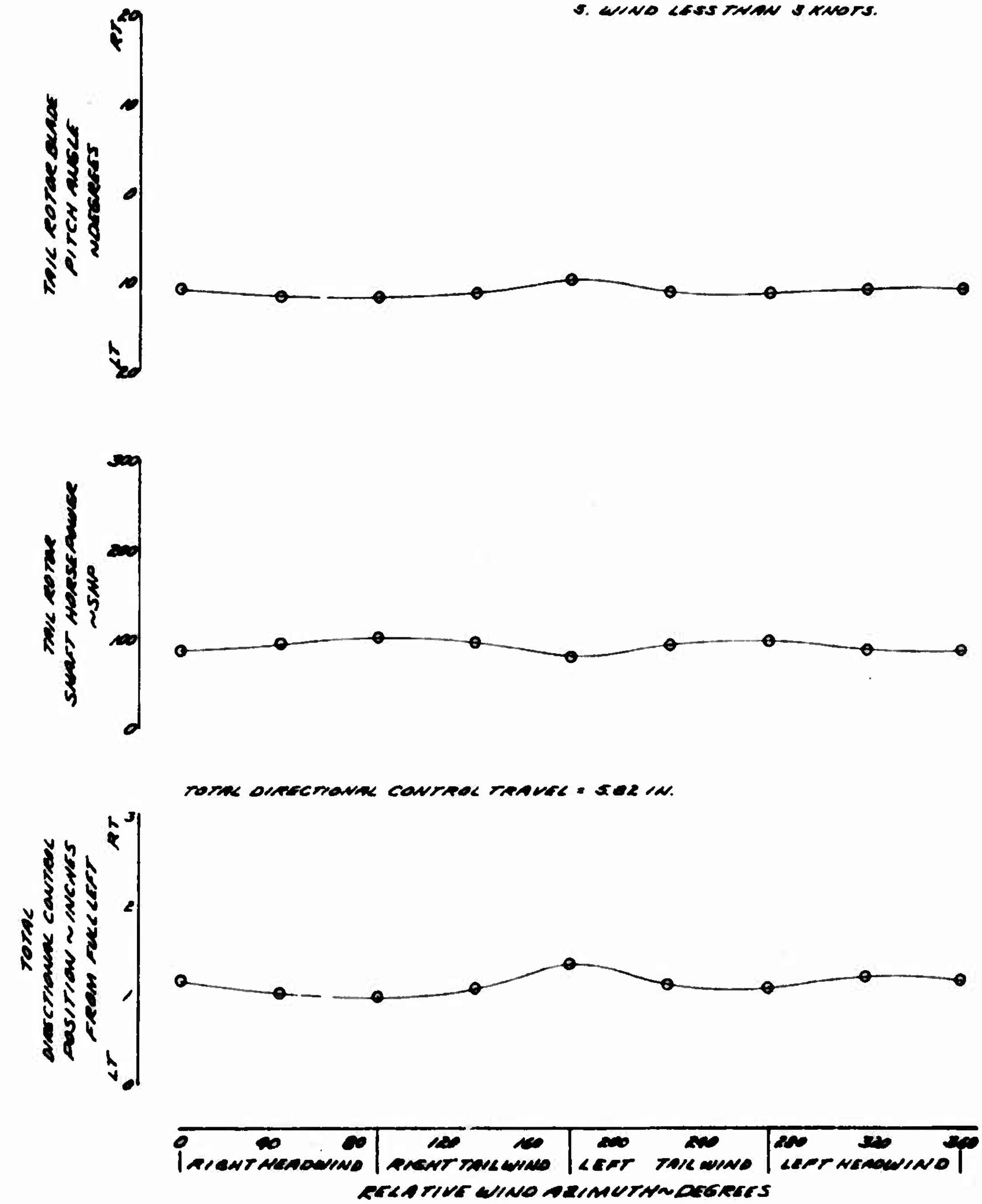


FIGURE [illegible]

DIRECTIONAL CONTROL AT VARIOUS RELATIVE WIND AZIMUTHS

AH-1G USA S/N 71-20983

| AVG GROSS WEIGHT (LB) | AVG DENSITY ALTITUDE (FT) | AVG OAT (°C) | AVG CG LOCATION (IN) | AVG ROTOR SPEED (RPM) | AVG $C_T$ | AVG TRUE AIRSPEED (KTAS) | CONFIG |
|---|---|---|---|---|---|---|---|
| 8360 | 2060 | 22.0 | 194.3 | 324 | .004926 | 10 | HOG |

NOTES:

1. TRUE AIRSPEED IS THE VECTORIAL SUM OF GROUND SPEED AND WIND VELOCITY.
2. GROUND SPEED DETERMINED WITH CALIBRATED PACE VEHICLE.
3. FULL LEFT DIRECTIONAL CONTROL = 12.[illegible] DEGREES TAIL ROTOR BLADE PITCH ANGLE.
4. FULL RIGHT DIRECTIONAL CONTROL = 10.3 DEGREES TAIL ROTOR BLADE PITCH ANGLE.
5. WIND LESS THAN 3 KNOTS.

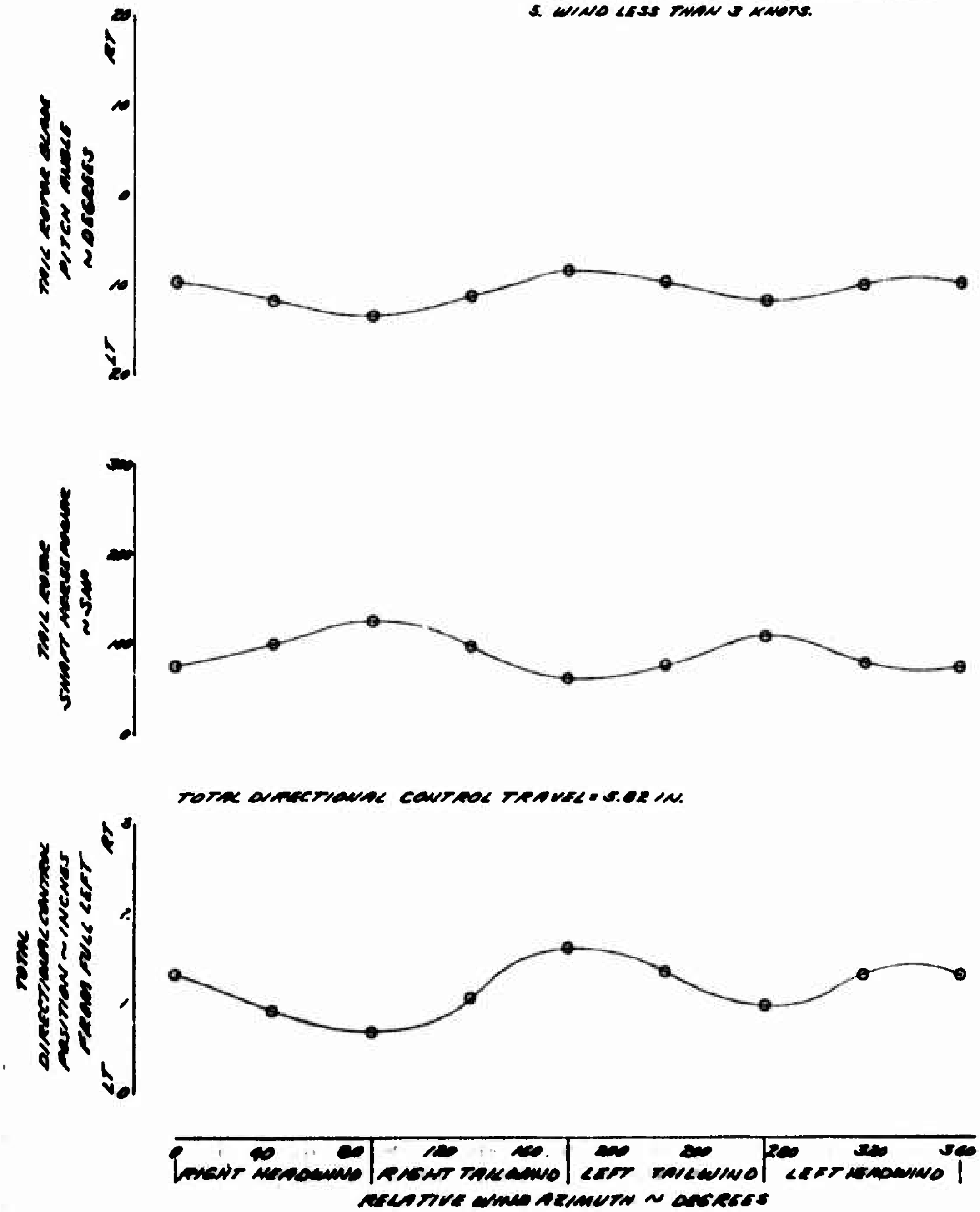


**FIGURE 51**

**DIRECTIONAL CONTROL AT VARIOUS RELATIVE WIND AZIMUTHS**

**AH-1G USA S/N 71-20985**

| AVG GROSS WEIGHT (LB) | AVG DENSITY ALTITUDE (FT) | AVG OAT (°C) | AVG CG LOCATION (IN.) | AVG ROTOR SPEED (RPM) | AVG $C_T$ | AVG TRUE AIRSPEED (KTAS) | CONFIG |
|---|---|---|---|---|---|---|---|
| 8360 | 2080 | 28.5 | 194.9 | 325 | .004701 | 15 | HOG |

NOTES:

1. TRUE AIRSPEED IS THE VECTORIAL SUM OF GROUND SPEED AND WIND VELOCITY.
2. GROUND SPEED DETERMINED WITH CALIBRATED PACE VEHICLE.
3. FULL LEFT DIRECTIONAL CONTROL = 17.7 DEGREES TAIL ROTOR BLADE PITCH ANGLE.
4. FULL RIGHT DIRECTIONAL CONTROL = 10.3 DEGREES TAIL ROTOR BLADE PITCH ANGLE.
5. WIND LESS THAN 3 KNOTS.

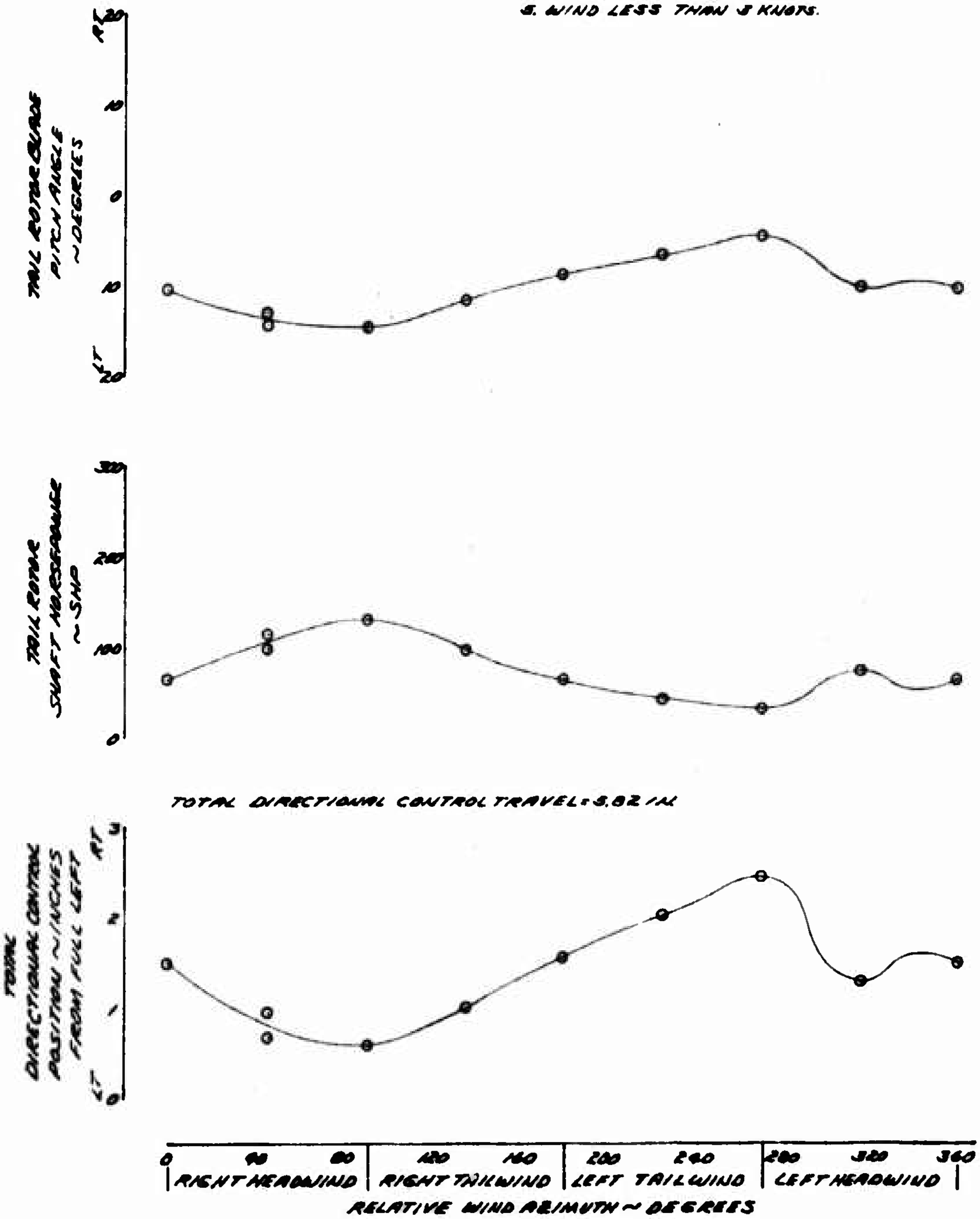


FIGURE 62

DIRECTIONAL CONTROL AT VARIOUS RELATIVE WIND AZIMUTHS

AH-1G USA S/N 71-20985

| AVG GROSS WEIGHT (LB) | AVG DENSITY ALTITUDE (FT) | AVG OAT (°C) | AVG CG LOCATION (M.S.) | AVG ROTOR SPEED (RPM) | AVG $C_T$ | AVG TRUE AIRSPEED (KTAS) | CONFIG |
|---|---|---|---|---|---|---|---|
| 8990 | 2060 | 20.0 | 139.9 | 325 | .004606 | 21 | HOG |

NOTES:

1. TRUE AIRSPEED IS THE VECTORIAL SUM OF GROUND SPEED AND WIND VELOCITY.
2. GROUND SPEED DETERMINED WITH CALIBRATED PACE VEHICLE.
3. FULL LEFT DIRECTIONAL CONTROL = 17.7 DEGREES TAIL ROTOR BLADE PITCH ANGLE.
4. FULL RIGHT DIRECTIONAL CONTROL = 10.3 DEGREES TAIL ROTOR BLADE PITCH ANGLE.
5. WIND LESS THAN 3 KNOTS.

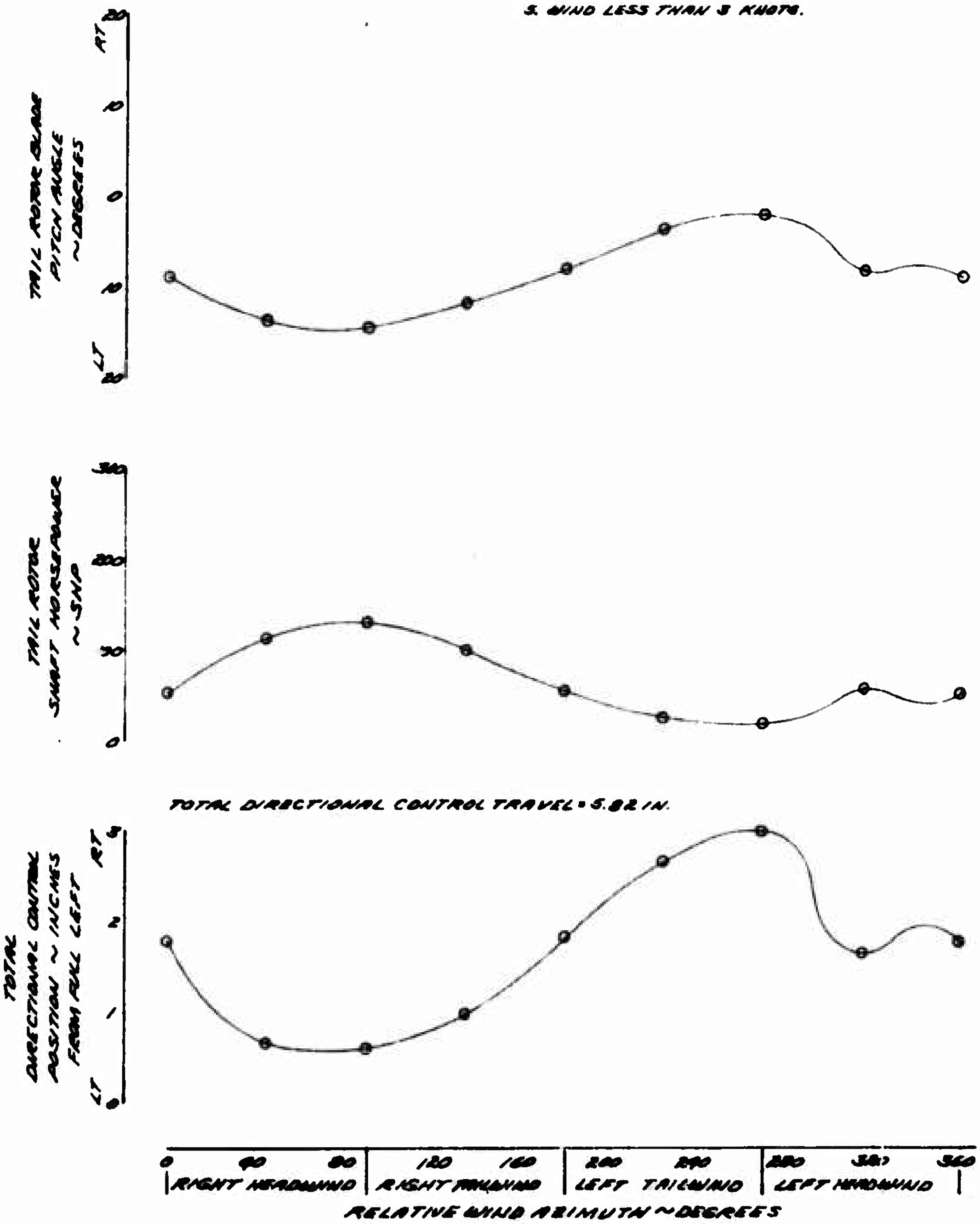


FIGURE 63

DIRECTIONAL CONTROL AT VARIOUS RELATIVE WIND AZIMUTHS

AH-1G USA S/N 71-20986

| AVG GROSS WEIGHT (LB) | AVG DENSITY ALTITUDE (FT) | AVG OAT (°C) | AVG CG LOCATION (IN.) | AVG ROTOR SPEED (RPM) | AVG $C_T$ | AVG TRUE AIRSPEED (KTAS) | CONFIG |
|---|---|---|---|---|---|---|---|
| 8360 | 2080 | 28.6 | 194.3 | 325 | .004701 | 26 | HOG |

NOTES:

1. TRUE AIRSPEED IS THE VECTORIAL SUM OF GROUND SPEED AND WIND VELOCITY.
2. GROUND SPEED DETERMINED WITH CALIBRATED PACE VEHICLE.
3. FULL LEFT DIRECTIONAL CONTROL = 17.7 DEGREES TAIL ROTOR BLADE PITCH ANGLE.
4. FULL RIGHT DIRECTIONAL CONTROL = 10.3 DEGREES TAIL ROTOR BLADE PITCH ANGLE.
5. WIND LESS THAN 3 KNOTS.

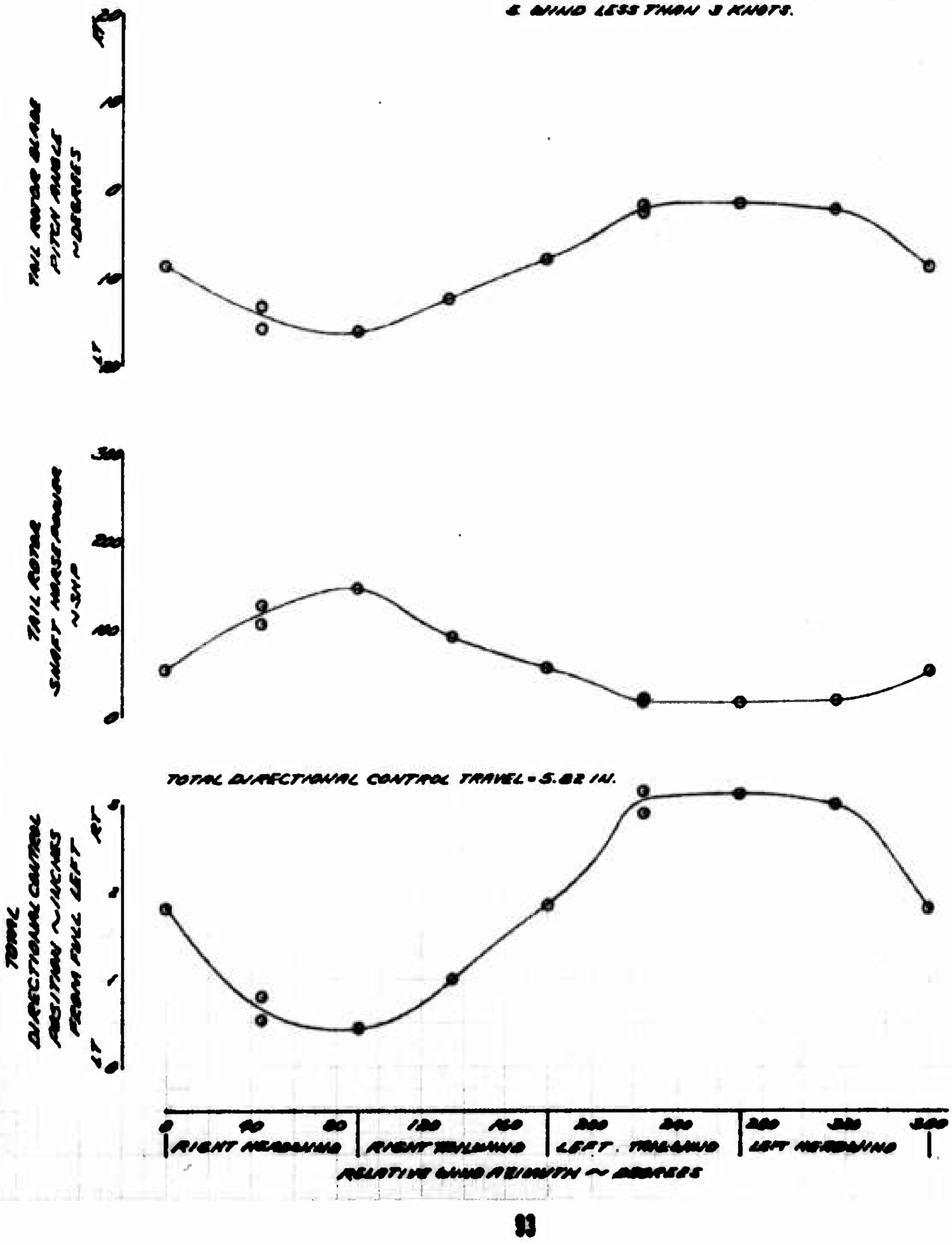


FIGURE [illegible]
DIRECTIONAL CONTROL AT VARIOUS RELATIVE WIND AZIMUTHS
AH-1G USA S/N 71-20985

| AVG GROSS WEIGHT (LB) | AVG DENSITY ALTITUDE (FT) | AVG OAT (°C) | AVG CG LOCATION (IN.) | AVG ROTOR SPEED (RPM) | AVG $C_T$ | AVG TRUE AIRSPEED (KTAS) | CONFIG |
|---|---|---|---|---|---|---|---|
| 8370 | 2060 | 28.0 | 194.9 | 326 | .004478 | 31 | HOG |

NOTES:
1. TRUE AIRSPEED IS THE VECTORIAL SUM OF GROUND SPEED AND WIND VELOCITY.
2. GROUND SPEED DETERMINED WITH CALIBRATED PACE VEHICLE.
3. FULL LEFT DIRECTIONAL CONTROL = 17.7 DEGREES TAIL ROTOR BLADE PITCH ANGLE.
4. FULL RIGHT DIRECTIONAL CONTROL = 10.3 DEGREES TAIL ROTOR BLADE PITCH ANGLE.
5. WIND LESS THAN 3 KNOTS.

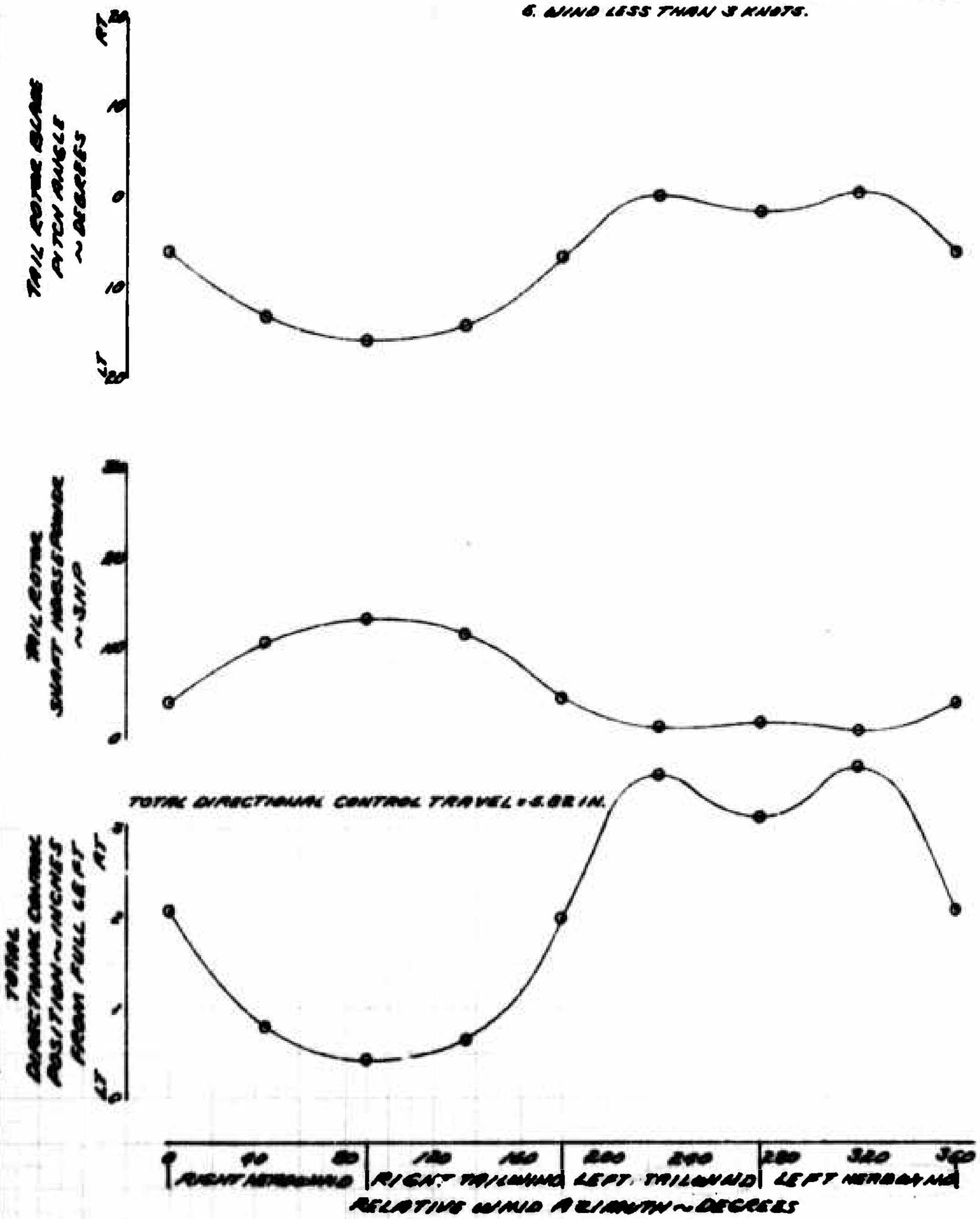


FIGURE 65

DIRECTIONAL CONTROL AT VARIOUS RELATIVE WIND AZIMUTHS

AH-1G USA S/N 71-20985

| AVG GROSS WEIGHT (LB) | AVG DENSITY ALTITUDE (FT) | AVG OAT (°C) | AVG CG LOCATION (IN.) | AVG ROTOR SPEED (RPM) | AVG $C_T$ | AVG TRUE AIRSPEED (KTAS) | CONFIG |
|---|---|---|---|---|---|---|---|
| 8360 | 2060 | 28.0 | 196.3 | 325 | .000637 | 30 | HOG |

NOTES:

1. TRUE AIRSPEED IS THE VECTORIAL SUM OF GROUND SPEED AND WIND VELOCITY.
2. GROUND SPEED DETERMINED WITH CALIBRATED PACE VEHICLE.
3. FULL LEFT DIRECTIONAL CONTROL = 17.7 DEGREES TAIL ROTOR BLADE PITCH ANGLE.
4. FULL RIGHT DIRECTIONAL CONTROL = 10.3 DEGREES TAIL ROTOR BLADE PITCH ANGLE.
5. WIND LESS THAN 3 KNOTS.

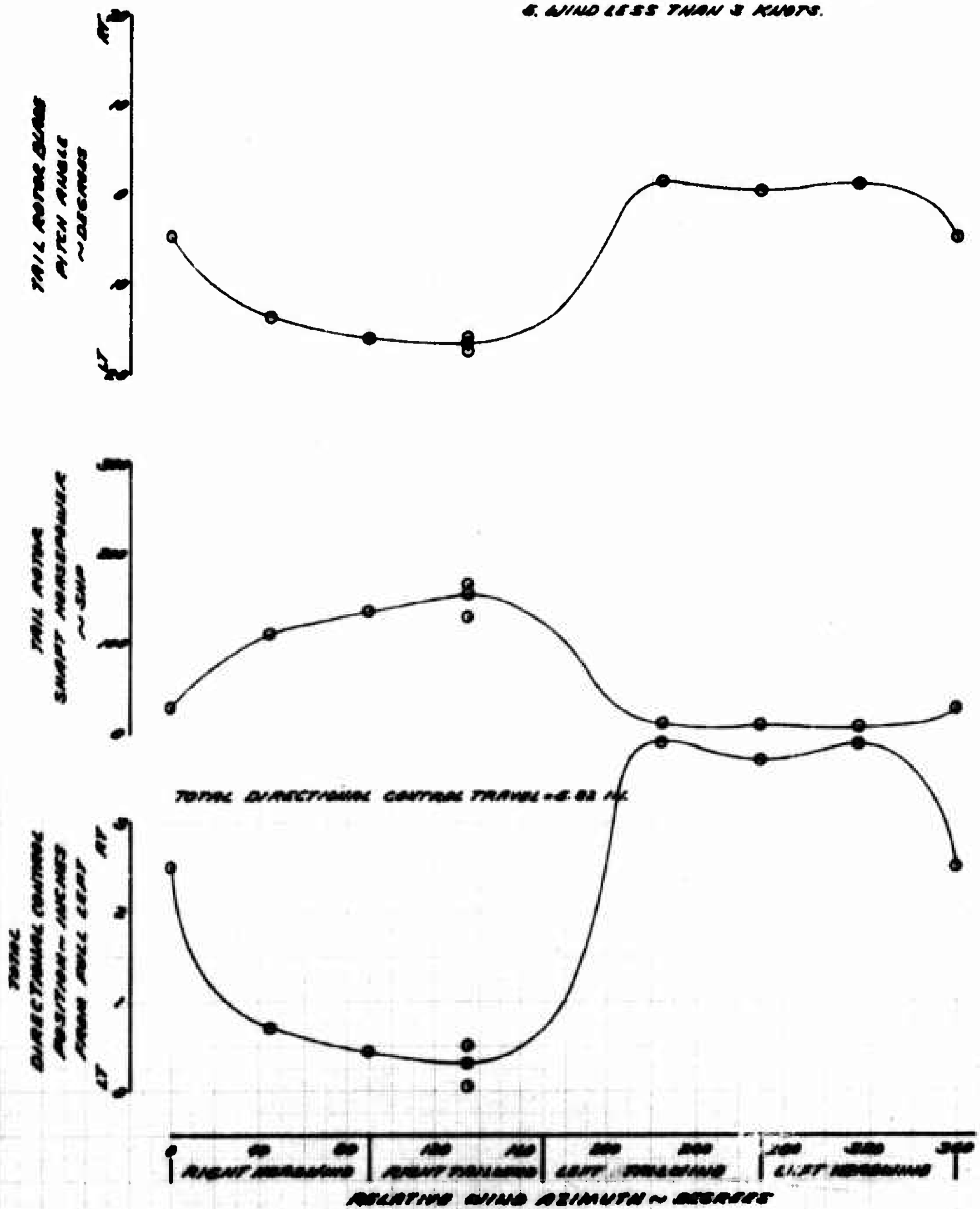


FIGURE 56

DIRECTIONAL CONTROL AT VARIOUS RELATIVE WIND AZIMUTHS

AH-1G USA S/N 71-20985

| AVG GROSS WEIGHT (LB) | AVG DENSITY ALTITUDE (FT) | AVG OAT (°C) | AVG CG LOCATION (IN.) | AVG ROTOR SPEED (RPM) | AVG $C_T$ | AVG TRUE AIRSPEED (KTAS) | CONFIG |
|---|---|---|---|---|---|---|---|
| 8960 | 2060 | 22.0 | 194.3 | 326 | .004648 | 43 | HOG |

NOTES:

1. TRUE AIRSPEED IS THE VECTORIAL SUM OF GROUND SPEED AND WIND VELOCITY.
2. GROUND SPEED DETERMINED WITH CALIBRATED PACE VEHICLE.
3. FULL LEFT DIRECTIONAL CONTROL = 17.7 DEGREES TAIL ROTOR BLADE PITCH ANGLE.
4. FULL RIGHT DIRECTIONAL CONTROL = 10.3 DEGREES TAIL ROTOR BLADE PITCH ANGLE.
5. WIND LESS THAN 3 KNOTS.

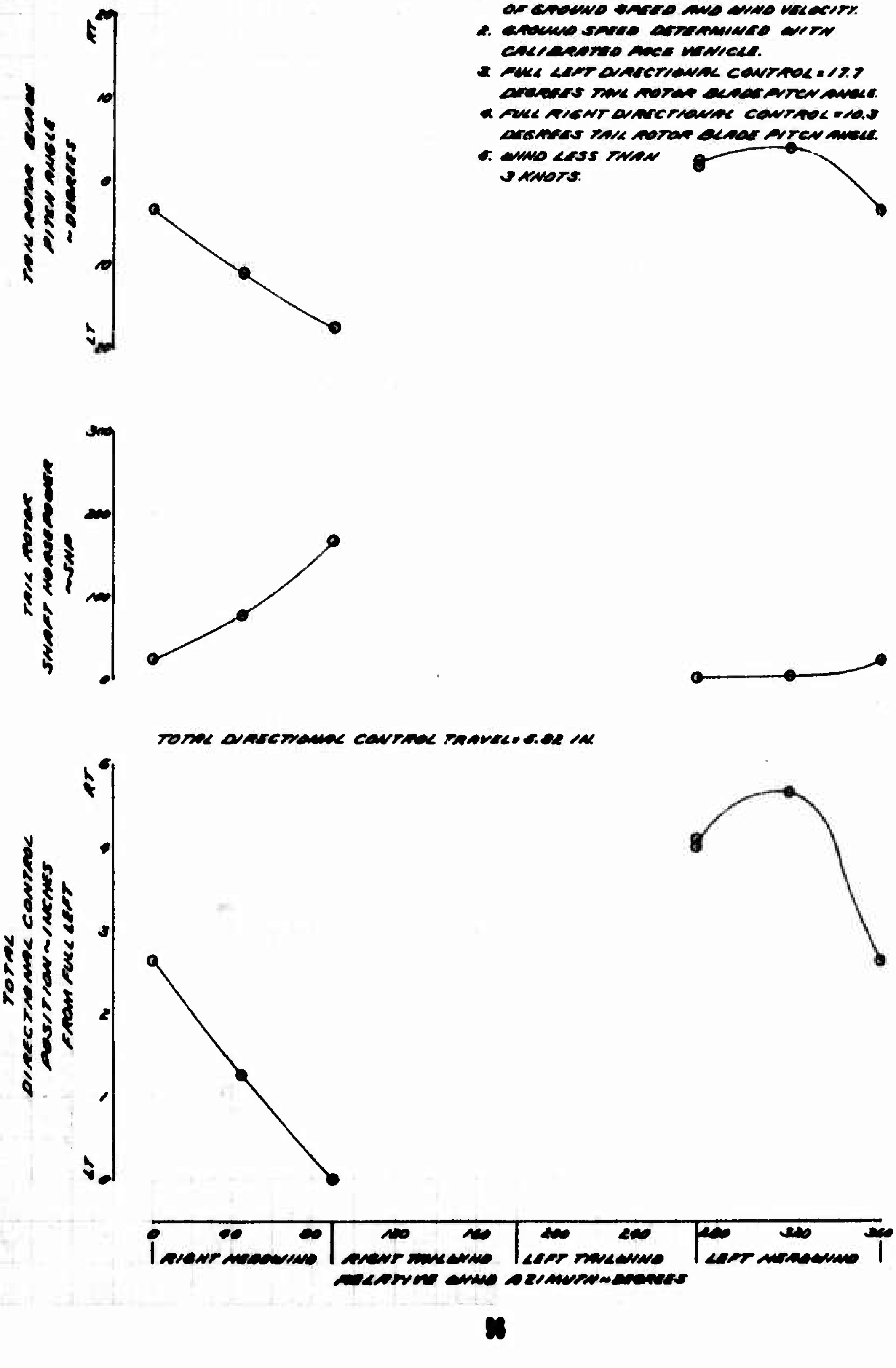


FIGURE 67

DIRECTIONAL CONTROL AT VARIOUS RELATIVE WIND AZIMUTHS

AH-1G USA S/N 71-20985

| AVG GROSS WEIGHT (LB) | AVG DENSITY ALTITUDE (FT) | AVG OAT (°C) | AVG CG LOCATION (IN) | AVG ROTOR SPEED (RPM) | AVG $C_T$ | AVG TRUE AIRSPEED (KTAS) | CONFIG |
|---|---|---|---|---|---|---|---|
| 8360 | 5360 | 10.5 | 134.3 | 324 | .004871 | 5 | HOG |

NOTES:

1. TRUE AIRSPEED IS THE VECTORIAL SUM OF GROUND SPEED AND WIND VELOCITY.
2. GROUND SPEED DETERMINED WITH CALIBRATED PACE VEHICLE.
3. FULL LEFT DIRECTIONAL CONTROL = 12.7 DEGREES TAIL ROTOR BLADE PITCH ANGLE.
4. FULL RIGHT DIRECTIONAL CONTROL = 10.3 DEGREES TAIL ROTOR BLADE PITCH ANGLE.
5. WIND LESS THAN 3 KNOTS.

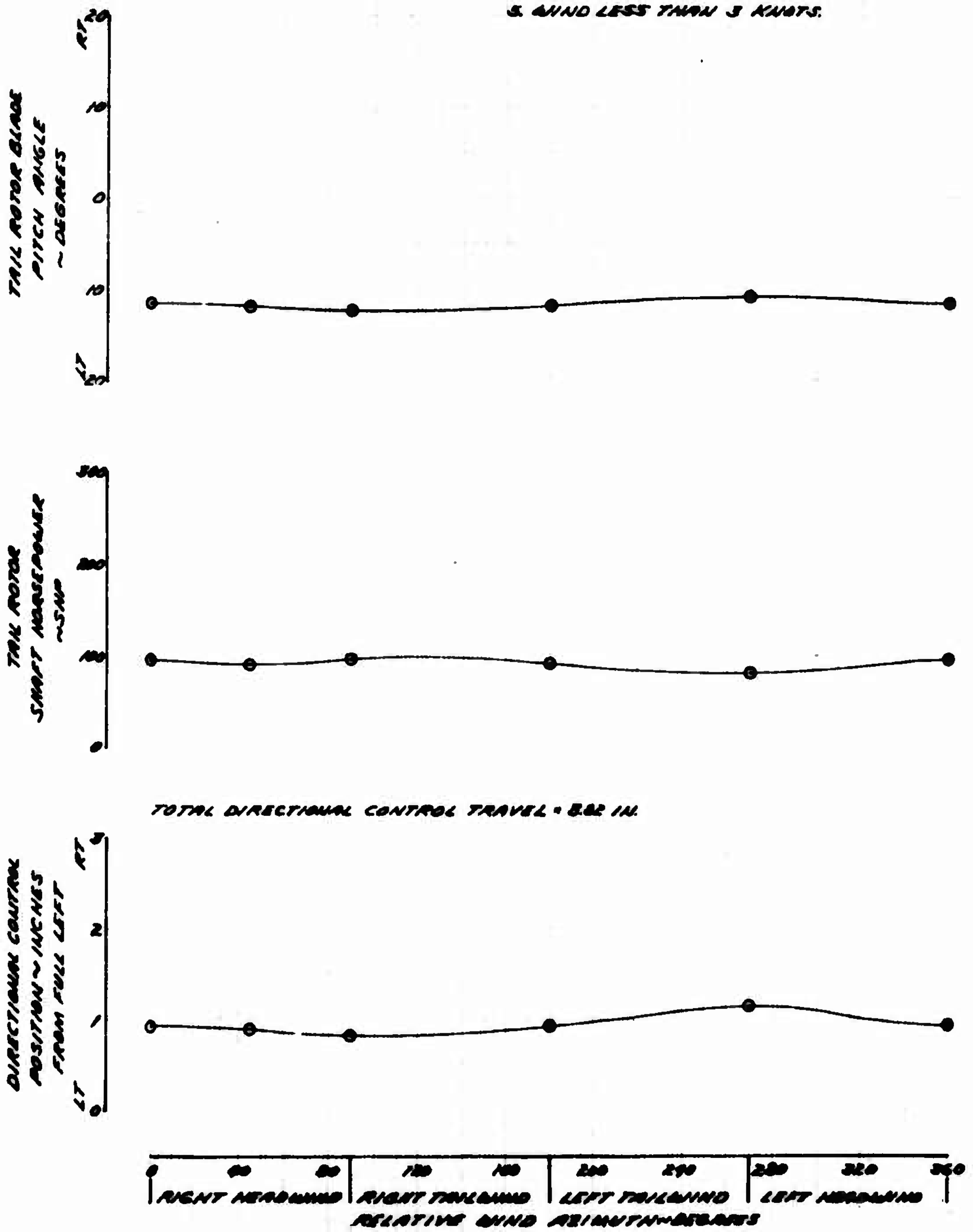


FIGURE 58

DIRECTIONAL CONTROL AT VARIOUS RELATIVE WIND AZIMUTHS

AH-1G USA S/N 71-20985

| AVG GROSS WEIGHT (LB) | AVG DENSITY ALTITUDE (FT) | AVG OAT (°C) | AVG CG LOCATION (IN.) | AVG ROTOR SPEED (RPM) | AVG $C_T$ | AVG TRUE AIRSPEED (KTAS) | CONFIG |
|---|---|---|---|---|---|---|---|
| 8900 | 5360 | 10.6 | 194.3 | 324 | .004839 | 10 | HOG |

NOTES:

1. TRUE AIRSPEED IS THE VECTORIAL SUM OF GROUND SPEED AND WIND VELOCITY.
2. GROUND SPEED DETERMINED WITH CALIBRATED PACE VEHICLE.
3. FULL LEFT DIRECTIONAL CONTROL = 17.7 DEGREES TAIL ROTOR BLADE PITCH ANGLE.
4. FULL RIGHT DIRECTIONAL CONTROL = 10.3 DEGREES TAIL ROTOR BLADE PITCH ANGLE.
5. WIND LESS THAN 3 KNOTS.

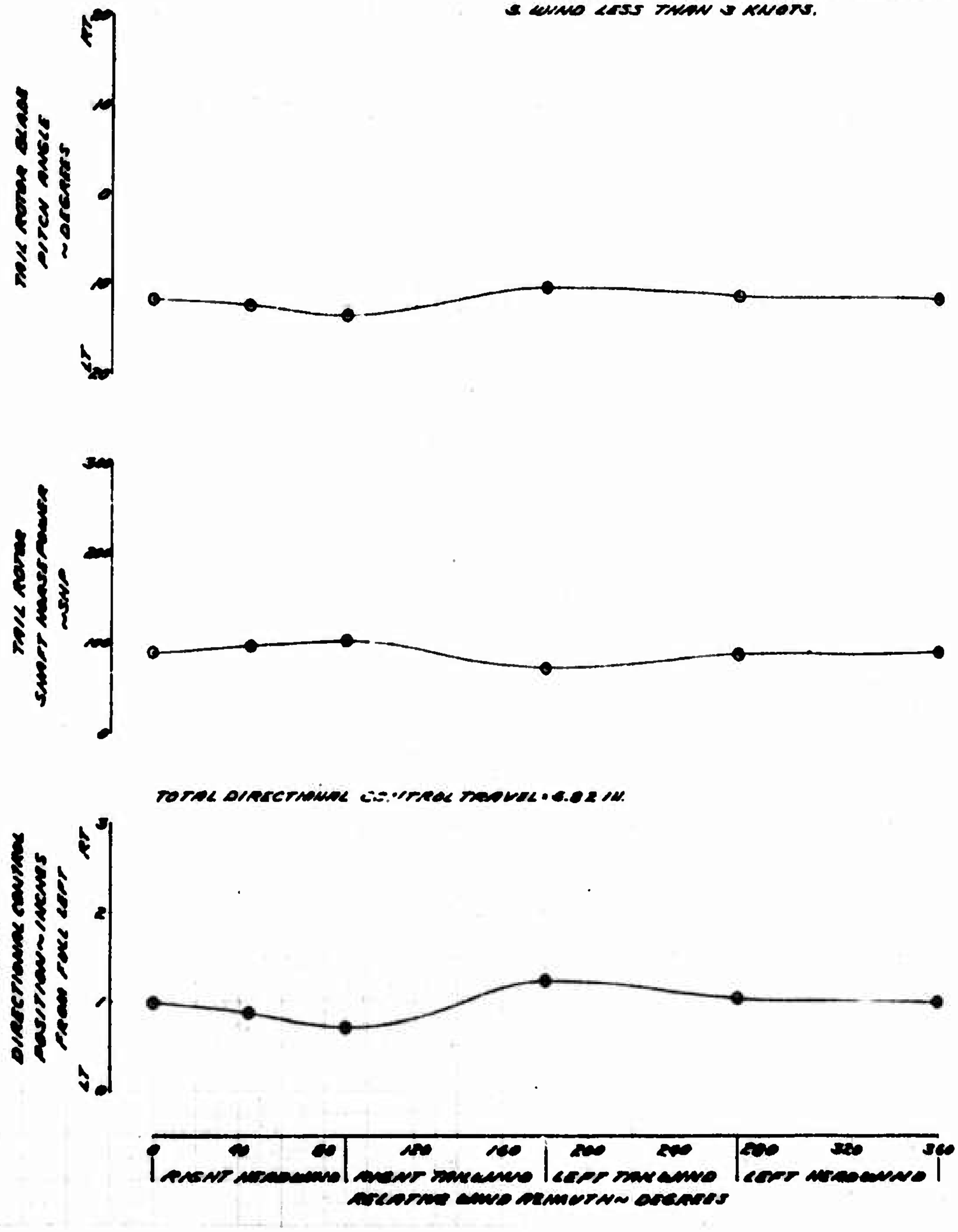


FIGURE 53

DIRECTIONAL CONTROL AT VARIOUS RELATIVE WIND AZIMUTHS

AH-1S USA S/N 71-20985

| AVG GROSS WEIGHT (LB) | AVG DENSITY ALTITUDE (FT) | AVG OAT (°C) | AVG CG LOCATION (IN.) | AVG ROTOR SPEED (RPM) | AVG $C_T$ | AVG TRUE AIRSPEED (KTAS) | [illegible] |
|---|---|---|---|---|---|---|---|
| 8390 | 6360 | 18.5 | 194.3 | 324 | .004863 | 16 | .100 |

NOTES:

1. TRUE AIRSPEED AS THE VECTORIAL SUM OF GROUND SPEED AND WIND VELOCITY.
2. GROUND SPEED DETERMINED WITH CALIBRATED PACE VEHICLE.
3. FULL LEFT DIRECTIONAL CONTROL = 17.7 DEGREES TAIL ROTOR BLADE PITCH ANGLE.
4. FULL RIGHT DIRECTIONAL CONTROL = 10.3 DEGREES TAIL ROTOR BLADE PITCH ANGLE.
5. WIND LESS THAN 3 KNOTS.

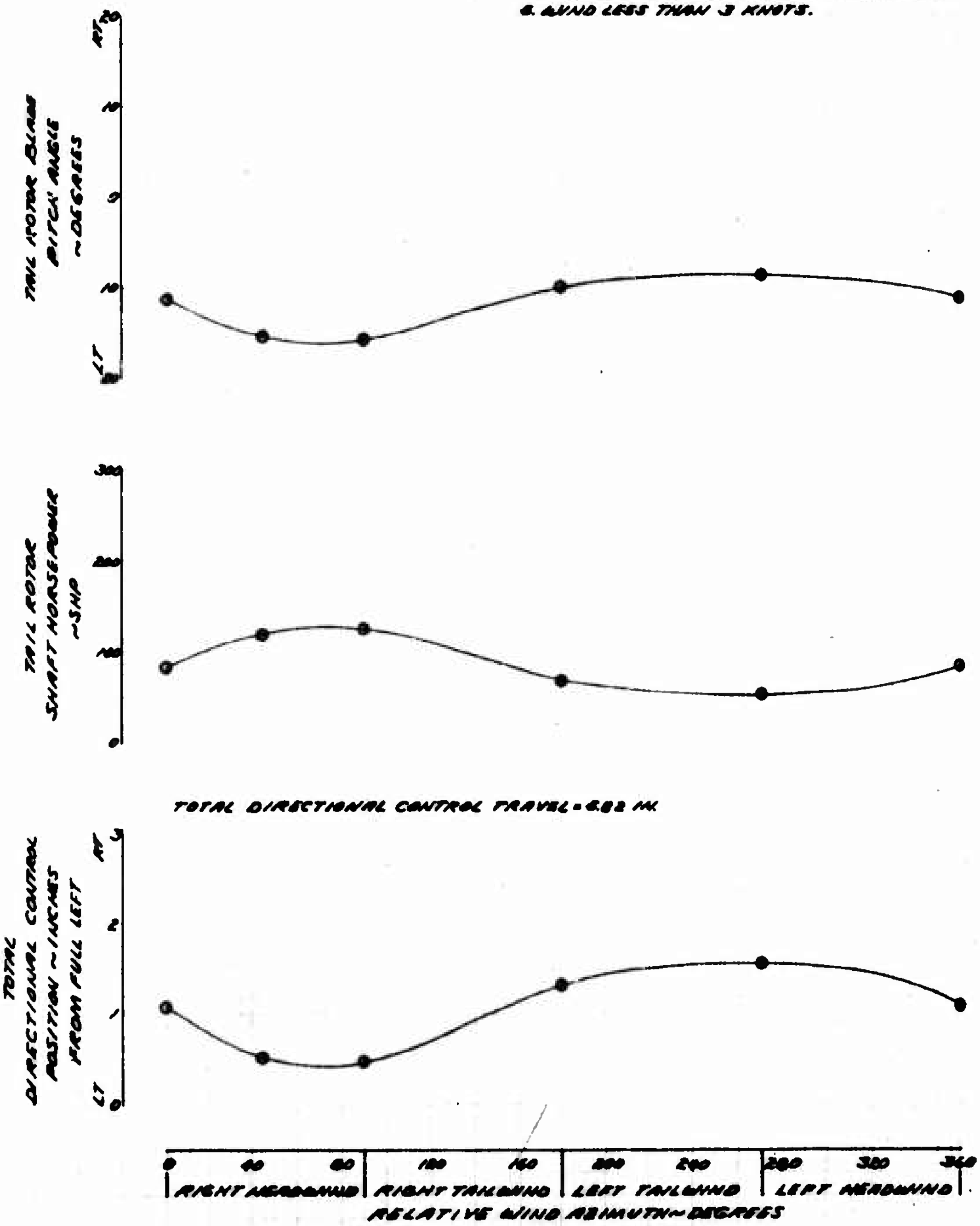


FIGURE 68

DIRECTIONAL CONTROL AT VARIOUS RELATIVE WIND AZIMUTHS

AH-1S USA S/N 71-20985

| AVG GROSS WEIGHT (LB) | AVG DENSITY ALTITUDE (FT) | AVG OAT (°C) | AVG CG LOCATION (IN) | AVG ROTOR SPEED (RPM) | AVG $C_T$ | AVG TRUE AIRSPEED (KTAS) | CONFIG |
|---|---|---|---|---|---|---|---|
| 8330 | 4360 | 18.6 | 194.9 | 324 | .004883 | 21 | HOG |

NOTES:

1. TRUE AIRSPEED AS THE VECTORIAL SUM OF GROUND SPEED AND WIND VELOCITY.
2. GROUND SPEED DETERMINED WITH CALIBRATED PACE VEHICLE.
3. FULL LEFT DIRECTIONAL CONTROL = 17.7 DEGREES TAIL ROTOR BLADE PITCH ANGLE.
4. FULL RIGHT DIRECTIONAL CONTROL = 10.3 DEGREES TAIL ROTOR BLADE PITCH ANGLE.
5. WIND LESS THAN 3 KNOTS.

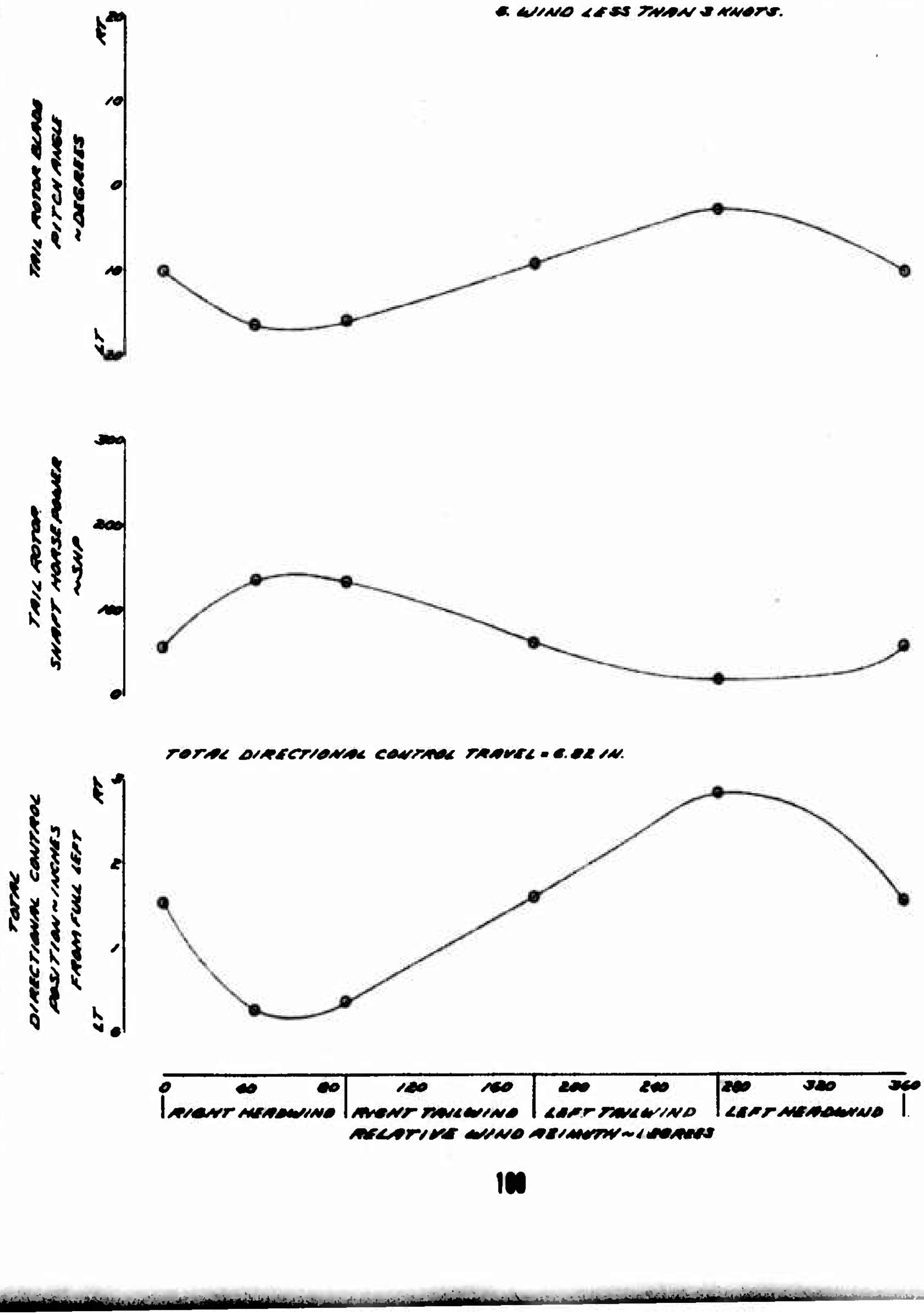


FIGURE 61

DIRECTIONAL CONTROL AT VARIOUS RELATIVE WIND AZIMUTHS

AH-1G USA S/N 71-20985

| AVG GROSS WEIGHT (LB) | AVG DENSITY ALTITUDE (FT) | AVG OAT (°C) | AVG CG LOCATION (IN) | AVG ROTOR SPEED (RPM) | AVG $C_T$ | AVG TRUE AIRSPEED (KTAS) | CONFIG |
|---|---|---|---|---|---|---|---|
| 8340 | 5900 | 13.0 | 197.3 | 325 | .004835 | 26 | HOG |

NOTES:

1. TRUE AIRSPEED IS THE VECTORIAL SUM OF GROUND SPEED AND WIND VELOCITY.
2. GROUND SPEED DETERMINED WITH CALIBRATED PACE VEHICLE.
3. FULL LEFT DIRECTIONAL CONTROL = 17.7 DEGREES TAIL ROTOR BLADE PITCH ANGLE.
4. FULL RIGHT DIRECTIONAL CONTROL = 10.3 DEGREES TAIL ROTOR BLADE PITCH ANGLE.
5. WIND LESS THAN 3 KNOTS.

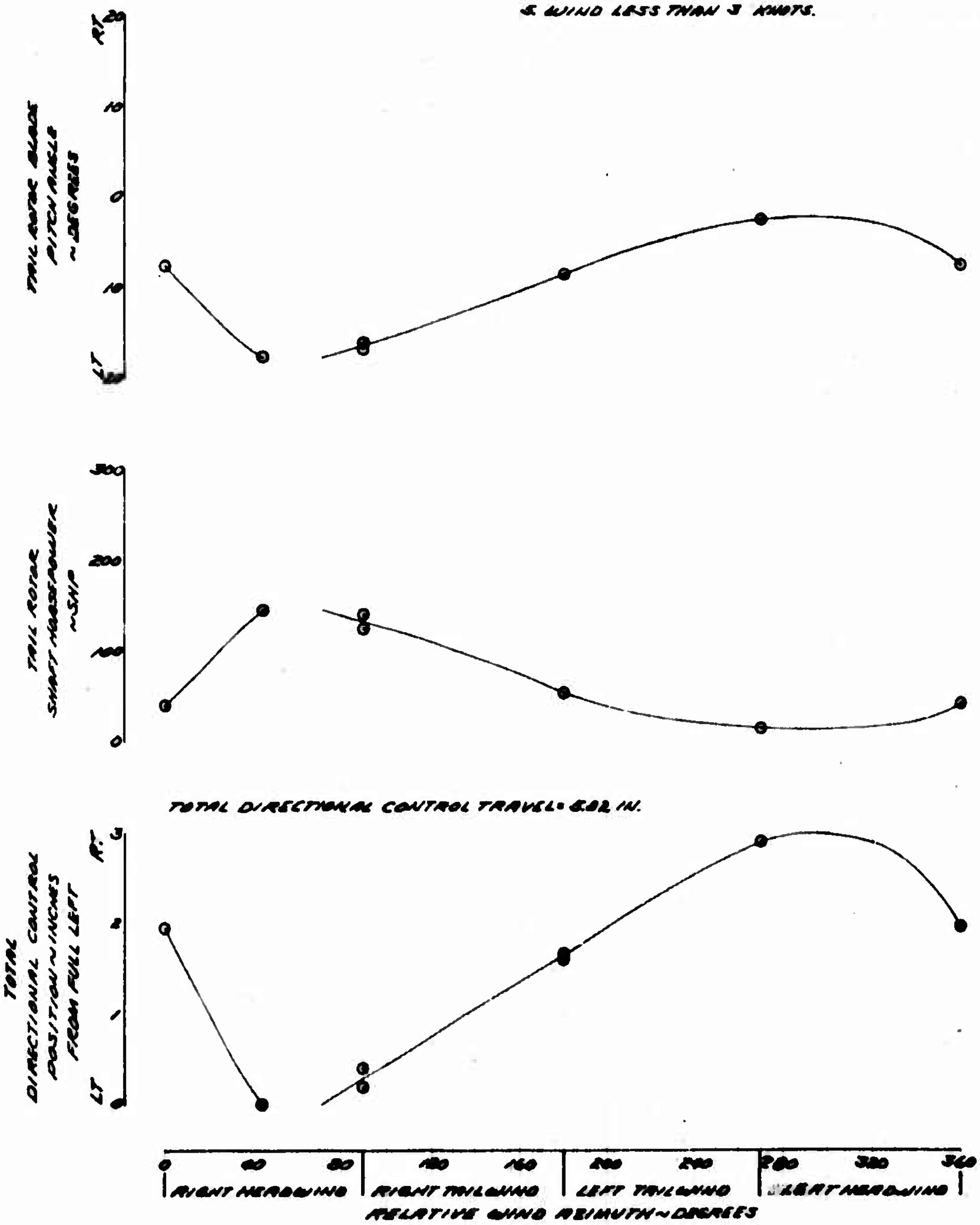


FIGURE 62

DIRECTIONAL CONTROL AT VARIOUS RELATIVE WIND AZIMUTHS

AH-1G USA S/N 71-20986

| AVG GROSS WEIGHT (LB) | AVG DENSITY ALTITUDE (FT) | AVG OAT (°C) | AVG CG LOCATION (IN.) | AVG ROTOR SPEED (RPM) | AVG $C_T$ | AVG TRUE AIRSPEED (KTAS) | CONFIG |
|---|---|---|---|---|---|---|---|
| 8330 | 5900 | 13.0 | 194.9 | 326 | .006831 | 31 | HOG |

NOTES:

1. TRUE AIRSPEED IS THE VECTORIAL SUM OF GROUND SPEED AND WIND VELOCITY.
2. GROUND SPEED DETERMINED WITH CALIBRATED PACE VEHICLE.
3. FULL LEFT DIRECTIONAL CONTROL = 17.7 DEGREES TAIL ROTOR BLADE PITCH ANGLE.
4. FULL RIGHT DIRECTIONAL CONTROL = 10.3 DEGREES TAIL ROTOR BLADE PITCH ANGLE.
5. WIND LESS THAN 3 KNOTS.

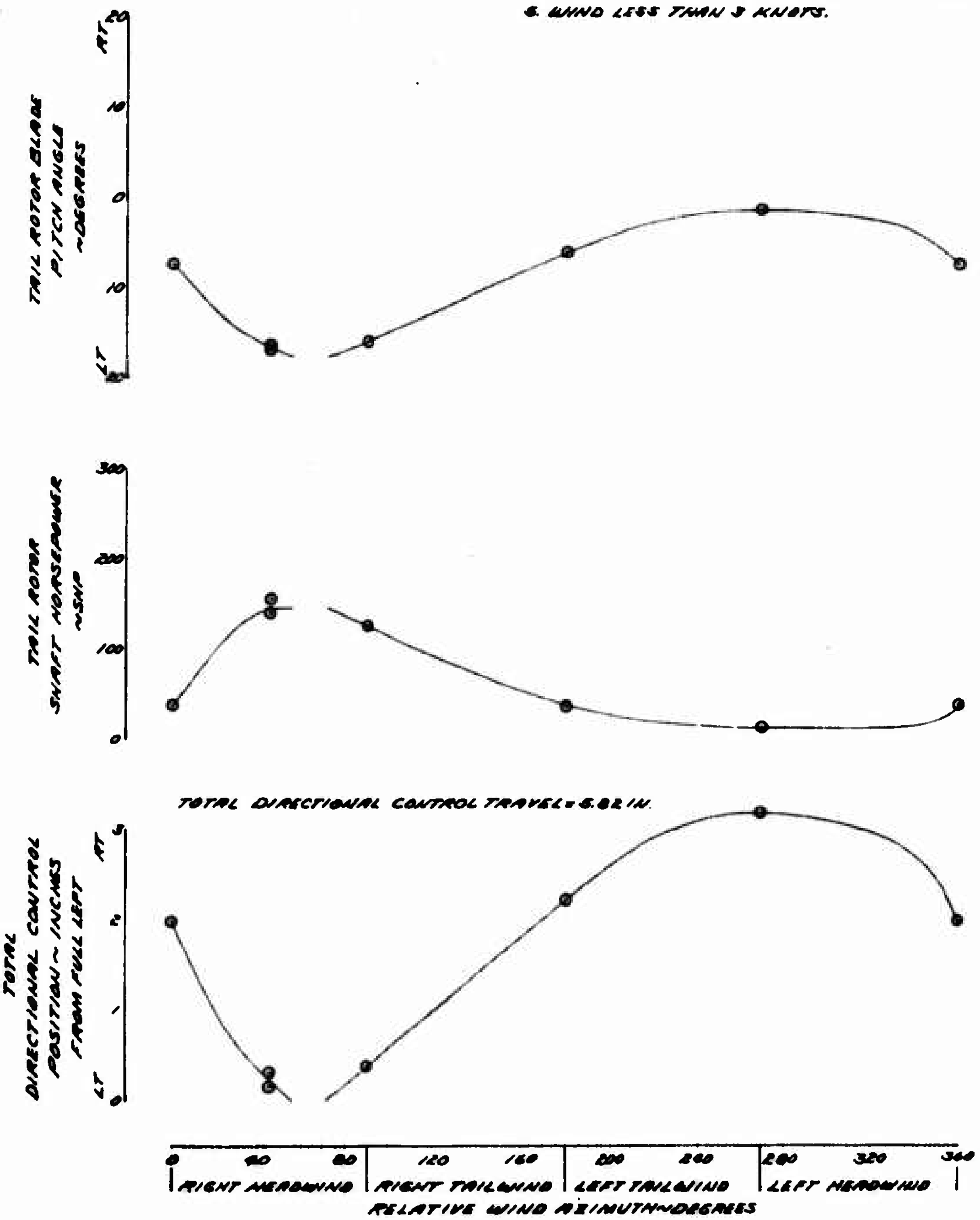


FIGURE 63

DIRECTIONAL CONTROL AT VARIOUS RELATIVE WIND AZIMUTHS

AH-1G USA S/N 71-20985

| AVG GROSS WEIGHT (LB) | AVG DENSITY ALTITUDE (FT) | AVG OAT (°C) | AVG CG LOCATION (IN.) | AVG ROTOR SPEED (RPM) | AVG $C_T$ | AVG TRUE AIRSPEED (KTAS) | CONFIG |
|---|---|---|---|---|---|---|---|
| 8530 | 5900 | 13.0 | 194.9 | 325 | .00488 | 38 | HOG |

NOTES:

1. TRUE AIRSPEED IS THE VECTORIAL SUM OF GROUND SPEED AND WIND VELOCITY.
2. GROUND SPEED DETERMINED WITH CALIBRATED PACE VEHICLE.
3. FULL LEFT DIRECTIONAL CONTROL = 17.7 DEGREES TAIL ROTOR BLADE PITCH ANGLE.
4. FULL RIGHT DIRECTIONAL CONTROL = 10.3 DEGREES TAIL ROTOR BLADE PITCH ANGLE.
5. WIND LESS THAN 3 KNOTS.

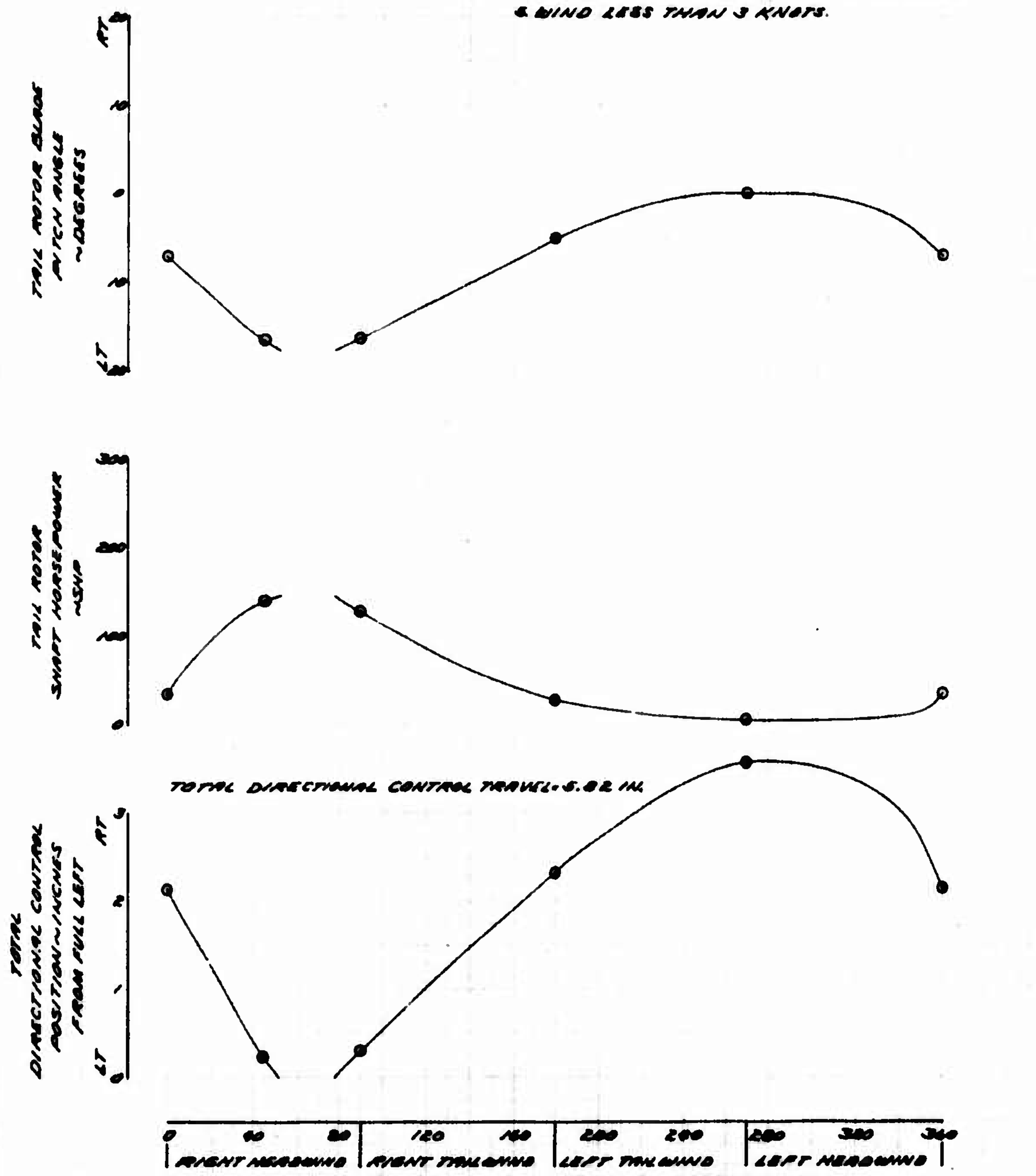


FIGURE 66

DIRECTIONAL CONTROL AT VARIOUS RELATIVE WIND AZIMUTHS

AH-1G USA S/N 71-20986

| AVG GROSS WEIGHT (LB) | AVG DENSITY ALTITUDE (FT) | AVG OAT (°C) | AVG CG LOCATION (IN) | AVG ROTOR SPEED (RPM) | AVG $C_T$ | AVG TRUE AIRSPEED (KTAS) | CONFIG |
|---|---|---|---|---|---|---|---|
| 8320 | 6360 | 10.5 | 194.9 | 326 | .004788 | 43 | |

NOTES:

1. TRUE AIRSPEED IS THE VECTORIAL SUM OF GROUND SPEED AND WIND VELOCITY.
2. GROUND SPEED DETERMINED WITH CALIBRATED PACE VEHICLE.
3. FULL LEFT DIRECTIONAL CONTROL = 12.7 DEGREES TAIL ROTOR BLADE PITCH ANGLE.
4. FULL RIGHT DIRECTIONAL CONTROL = 10.3 DEGREES TAIL ROTOR BLADE PITCH ANGLE.
5. WIND LESS THAN 3 KNOTS.

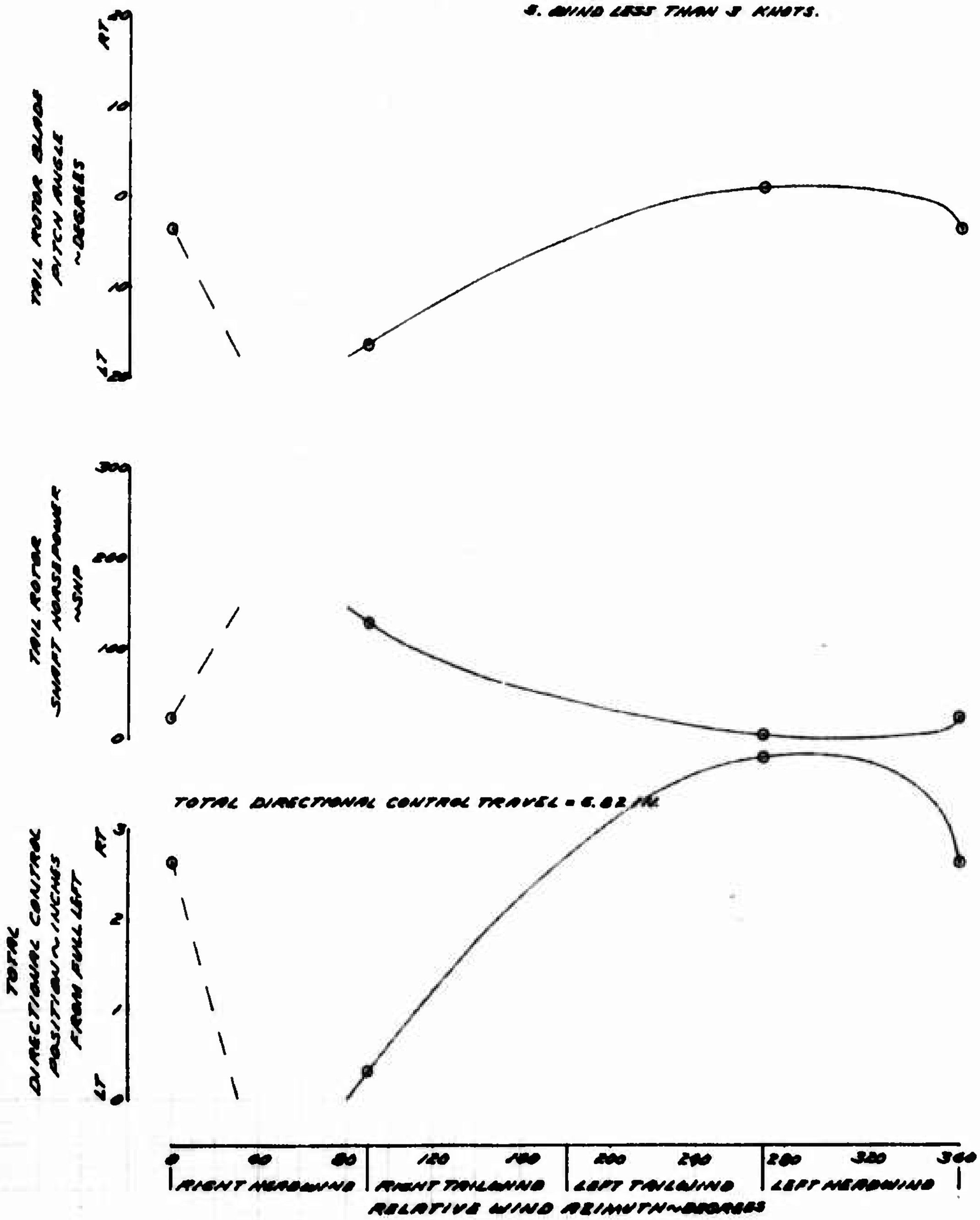


FIGURE 6[illegible]

<u>DIRECTIONAL CONTROL AT VARIOUS RELATIVE WIND AZIMUTHS</u>

AH-1G USA S/N 71-20985

| AVG GROSS WEIGHT (LB) | AVG DENSITY ALTITUDE (FT) | AVG OAT (°C) | AVG CG LOCATION (IN.) | AVG ROTOR SPEED (RPM) | AVG $C_T$ | AVG TRUE AIRSPEED (KTAS) | CONFIG |
|---|---|---|---|---|---|---|---|
| 8080 | 10000 | 3.0 | 194.3 | 324 | .005082 | 5 | [illegible] |

<u>NOTES:</u>

1. TRUE AIRSPEED IS THE VECTORIAL SUM OF GROUND SPEED AND WIND VELOCITY.
2. GROUND SPEED DETERMINED WITH CALIBRATED PACE VEHICLE.
3. FULL LEFT DIRECTIONAL CONTROL = 17.7 DEGREES TAIL ROTOR BLADE PITCH ANGLE.
4. FULL RIGHT DIRECTIONAL CONTROL = 10.3 DEGREES TAIL ROTOR BLADE PITCH ANGLE.
5. WIND LESS THAN 3 KNOTS.

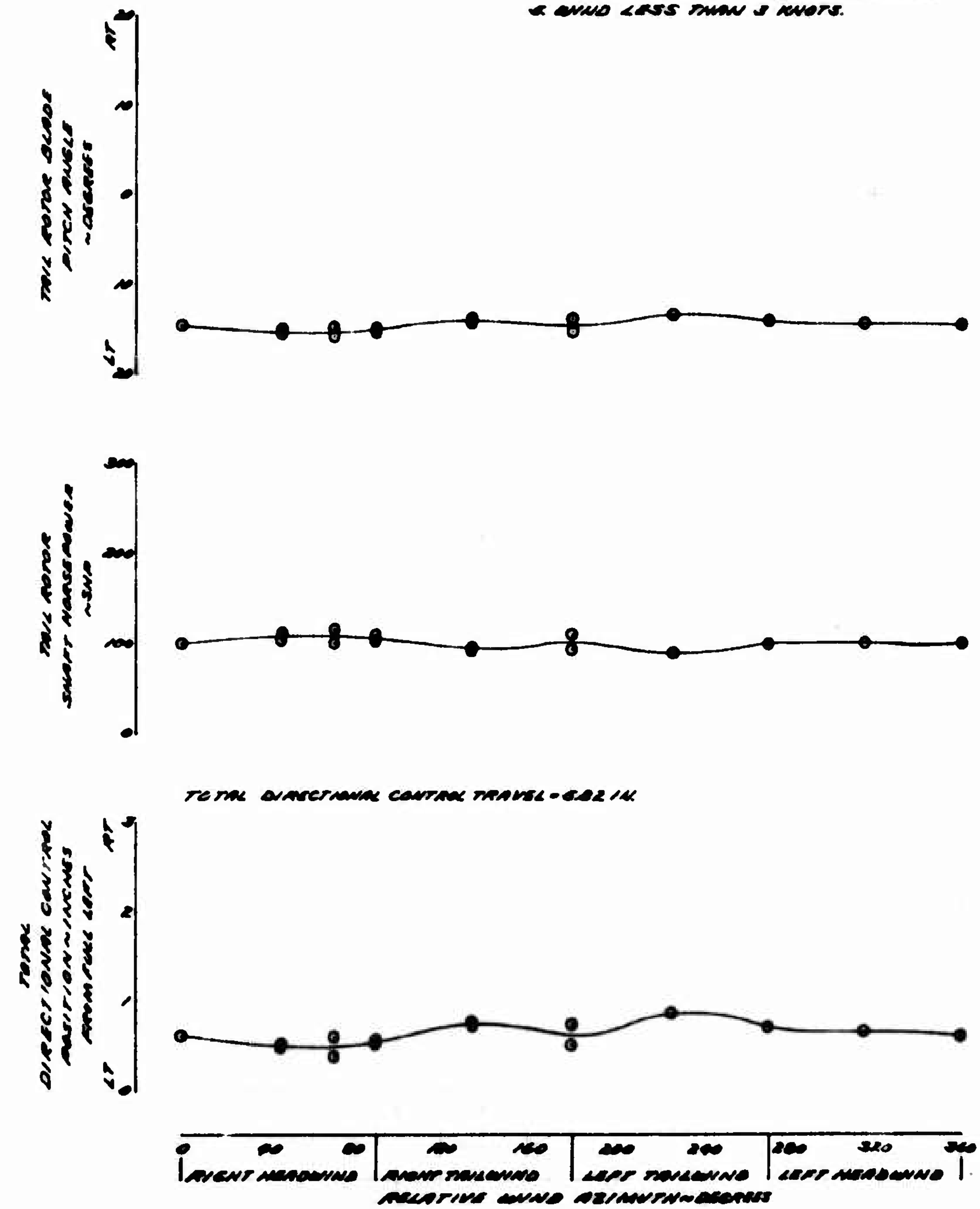


FIGURE 46

DIRECTIONAL CONTROL AT VARIOUS RELATIVE WIND AZIMUTHS

AH-1G USA S/N 71-20985

| AVG GROSS WEIGHT (LB) | AVG DENSITY ALTITUDE (FT) | AVG OAT (°C) | AVG CG LOCATION (IN.) | AVG ROTOR SPEED (RPM) | AVG $C_T$ | AVG TRUE AIRSPEED (KTAS) | CONFIG |
|---|---|---|---|---|---|---|---|
| 8080 | 10340 | 2.5 | 194.3 | 324 | .005836 | 10 | HOG |

NOTES:

1. TRUE AIRSPEED IS THE VECTORIAL SUM OF GROUND SPEED AND WIND VELOCITY.
2. GROUND SPEED DETERMINED WITH CALIBRATED PACE VEHICLE.
3. FULL LEFT DIRECTIONAL CONTROL = 17.7 DEGREES TAIL ROTOR BLADE PITCH ANGLE.
4. FULL RIGHT DIRECTIONAL CONTROL = 10.3 DEGREES TAIL ROTOR BLADE PITCH ANGLE.
5. WIND LESS THAN 3 KNOTS.

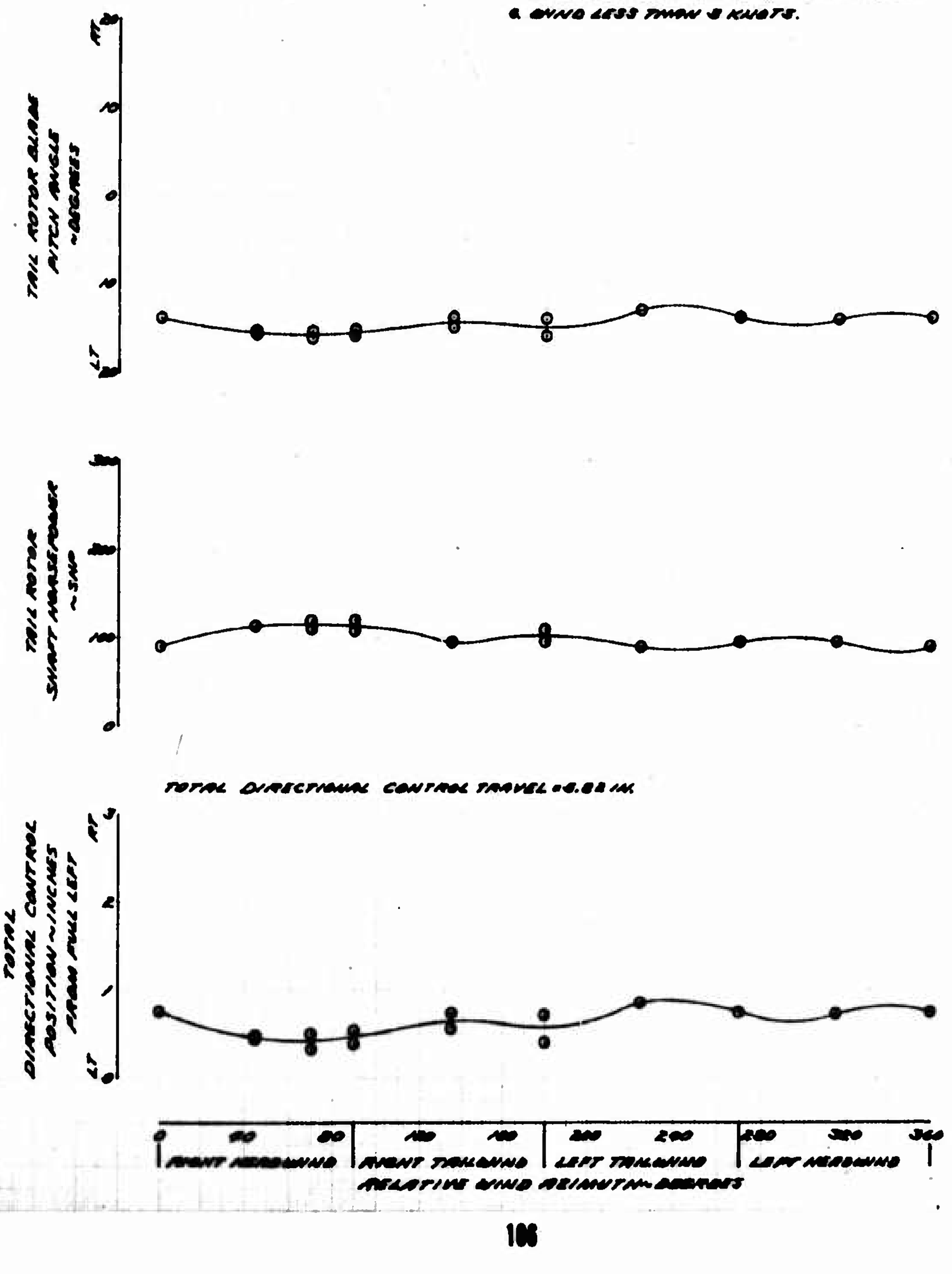


FIGURE 67

DIRECTIONAL CONTROL AT VARIOUS RELATIVE WIND AZIMUTHS

AH-1G USA S/N 71-20985

| AVG GROSS WEIGHT (LB) | AVG DENSITY ALTITUDE (FT) | AVG OAT (°C) | AVG CG LOCATION (IN) | ROTOR SPEED (RPM) | AVG $C_T$ | AVG TRUE AIRSPEED (KTAS) | CONFIG |
|---|---|---|---|---|---|---|---|
| 8060 | 10980 | 2.5 | 194.3 | 329 | .0065380 | 15 | HOG |

NOTES:

1. TRUE AIRSPEED AS THE VECTORIAL SUM OF GROUND SPEED AND WIND VELOCITY
2. GROUND SPEED DETERMINED WITH CALIBRATED PACE VEHICLE.
3. FULL LEFT DIRECTIONAL CONTROL = 17.7 DEGREES TAIL ROTOR BLADE PITCH ANGLE.
4. FULL RIGHT DIRECTIONAL CONTROL = 18.3 DEGREES TAIL ROTOR BLADE PITCH ANGLE.
5. WIND LESS THAN 3 KNOTS.

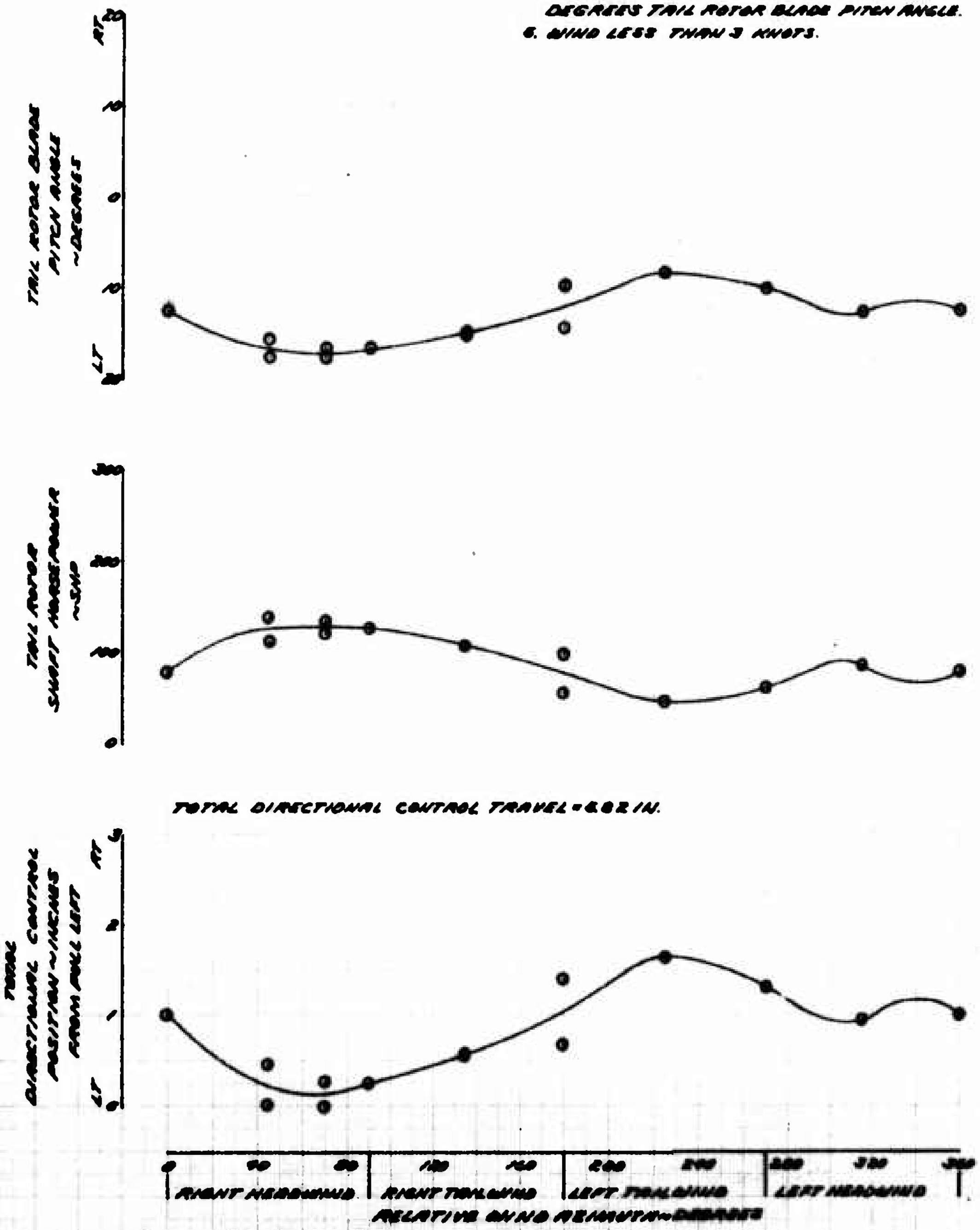


FIGURE 68

DIRECTIONAL CONTROL AT VARIOUS RELATIVE WIND AZIMUTHS

AH-1G USA S/N 71-20985

| AVG GROSS WEIGHT (LB) | AVG DENSITY ALTITUDE (FT) | AVG OAT (°C) | AVG CG LOCATION (IN.) | AVG ROTOR SPEED (RPM) | AVG $C_T$ | AVG TRUE AIRSPEED (KTAS) | CONFIG |
|---|---|---|---|---|---|---|---|
| 8060 | 11000 | 10.0 | 194.3 | 324 | .006633 | 21 | HOG |

NOTES:

1. TRUE AIRSPEED IS THE VECTORIAL SUM OF GROUND SPEED AND WIND VELOCITY
2. GROUND SPEED DETERMINED WITH CALIBRATED PACE VEHICLE.
3. FULL LEFT DIRECTIONAL CONTROL = 17.7 DEGREES TAIL ROTOR BLADE PITCH ANGLE.
4. FULL RIGHT DIRECTIONAL CONTROL = 10.3 DEGREES TAIL ROTOR BLADE PITCH ANGLE.
5. WIND LESS THAN 3 KNOTS.

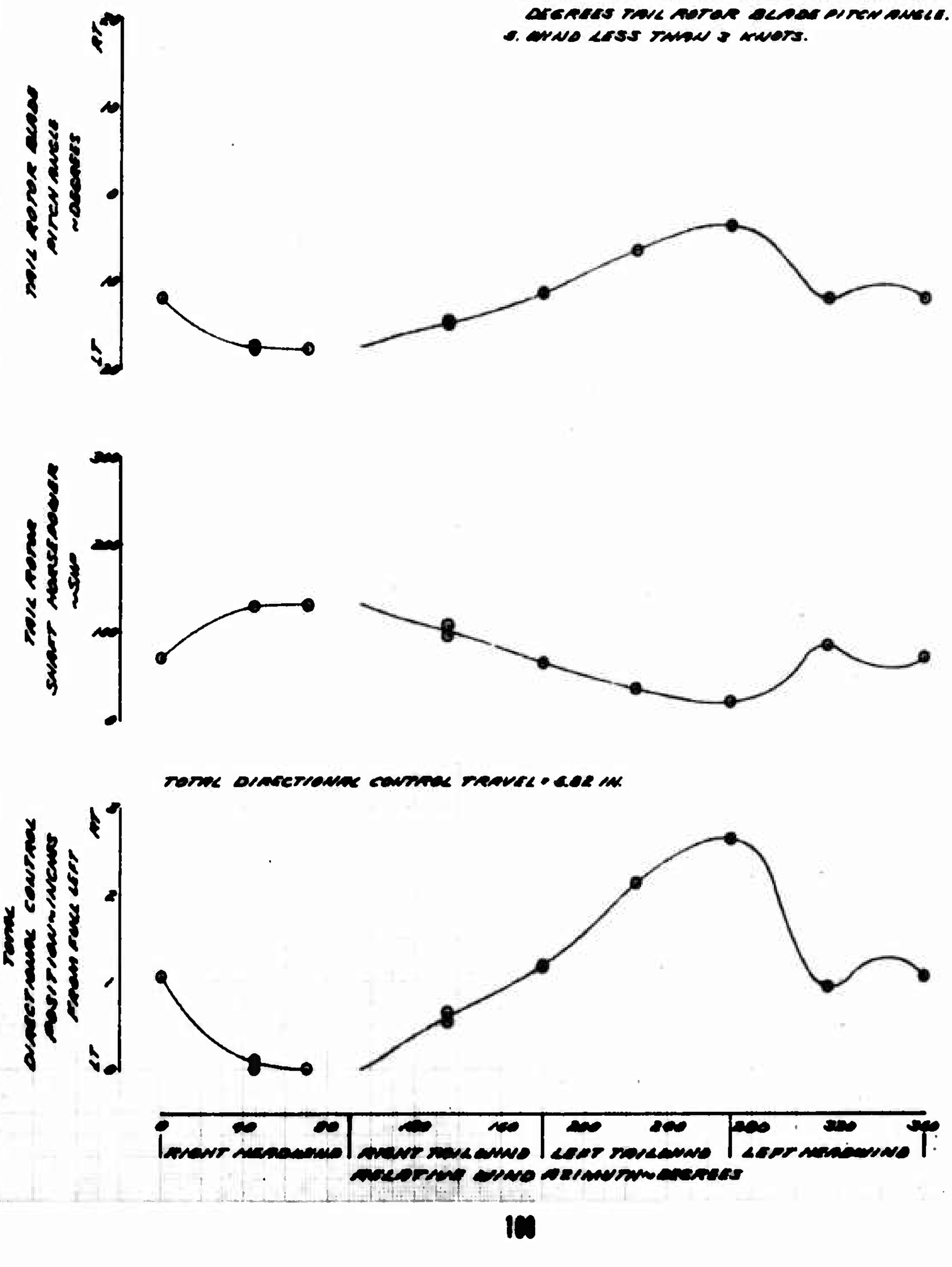


FIGURE 63

DIRECTIONAL CONTROL AT VARIOUS RELATIVE WIND AZIMUTHS

AH-1G USA S/N 71-20898

| AVG GROSS WEIGHT (LB) | AVG DENSITY ALTITUDE (FT) | AVG OAT (°C) | AVG CG LOCATION (IN) | AVG ROTOR SPEED (RPM) | AVG $C_T$ | AVG TRUE AIRSPEED (KTAS) | CONFIG |
|---|---|---|---|---|---|---|---|
| 8070 | 10300 | 9.0 | 194.3 | 326 | .003550 | 26 | HOG |

NOTES:

1. TRUE AIRSPEED IS THE VECTORIAL SUM OF GROUND SPEED AND WIND VELOCITY.
2. GROUND SPEED DETERMINED WITH CALIBRATED PACE VEHICLE.
3. FULL LEFT DIRECTIONAL CONTROL=17.7 DEGREES TAIL ROTOR BLADE PITCH ANGLE.
4. FULL RIGHT DIRECTIONAL CONTROL=10.3 DEGREES TAIL ROTOR BLADE PITCH ANGLE.
5. WIND LESS THAN 3 KNOTS.

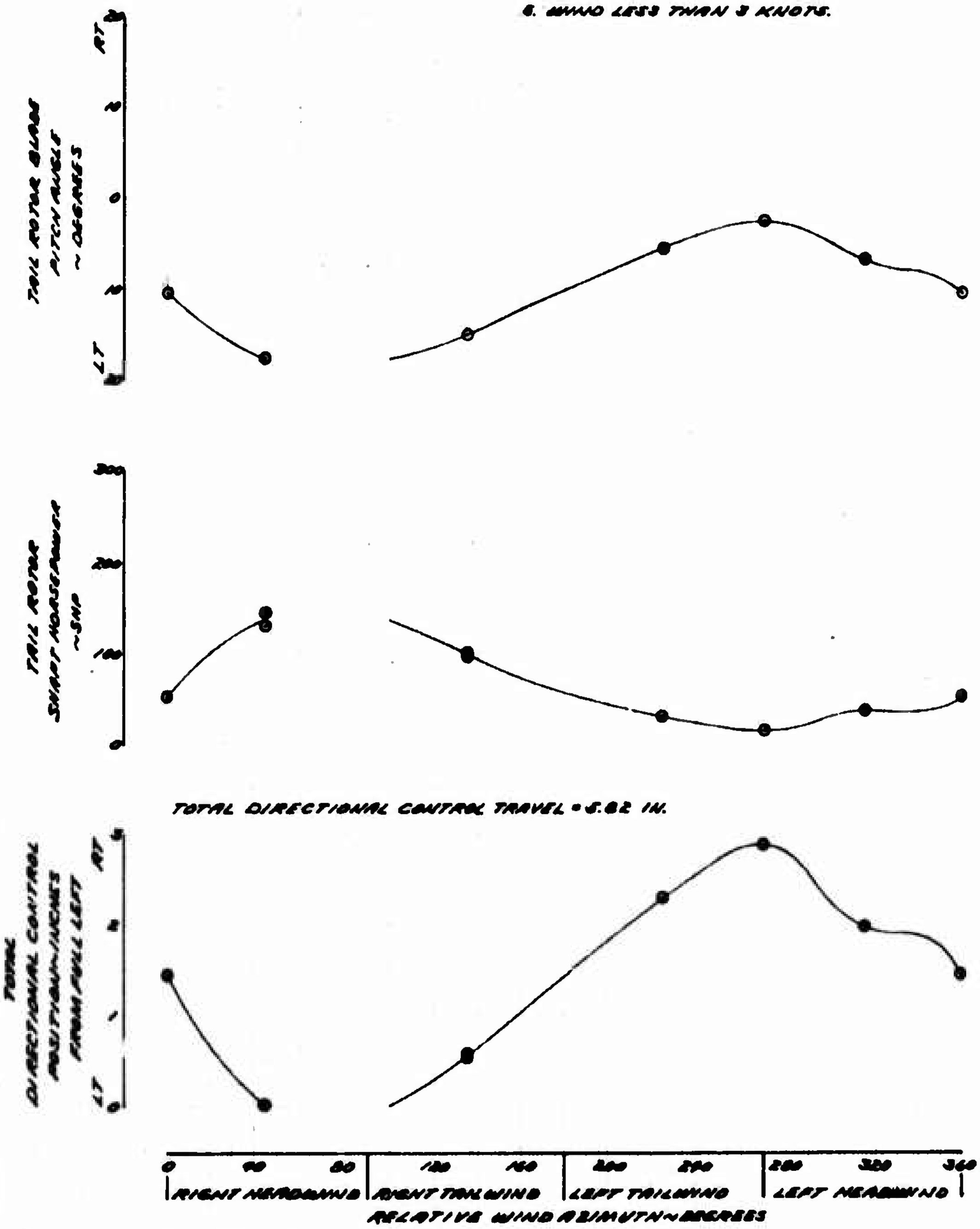


FIGURE 30

TRIMMED SIDEWARD AND REARWARD FLIGHT

AH-1G USA S/N 71-20985

| AVG GROSS WEIGHT (LB) | AVG DENSITY ALTITUDE (FT) | AVG OAT (°C) | AVG CG LOCATION (IN) | AVG ROTOR SPEED (RPM) | AVG $C_T$ | CONFIG |
|---|---|---|---|---|---|---|
| 8360 | 2020 | 27.6 | 134.9 | 325 | .004683 | HOG |

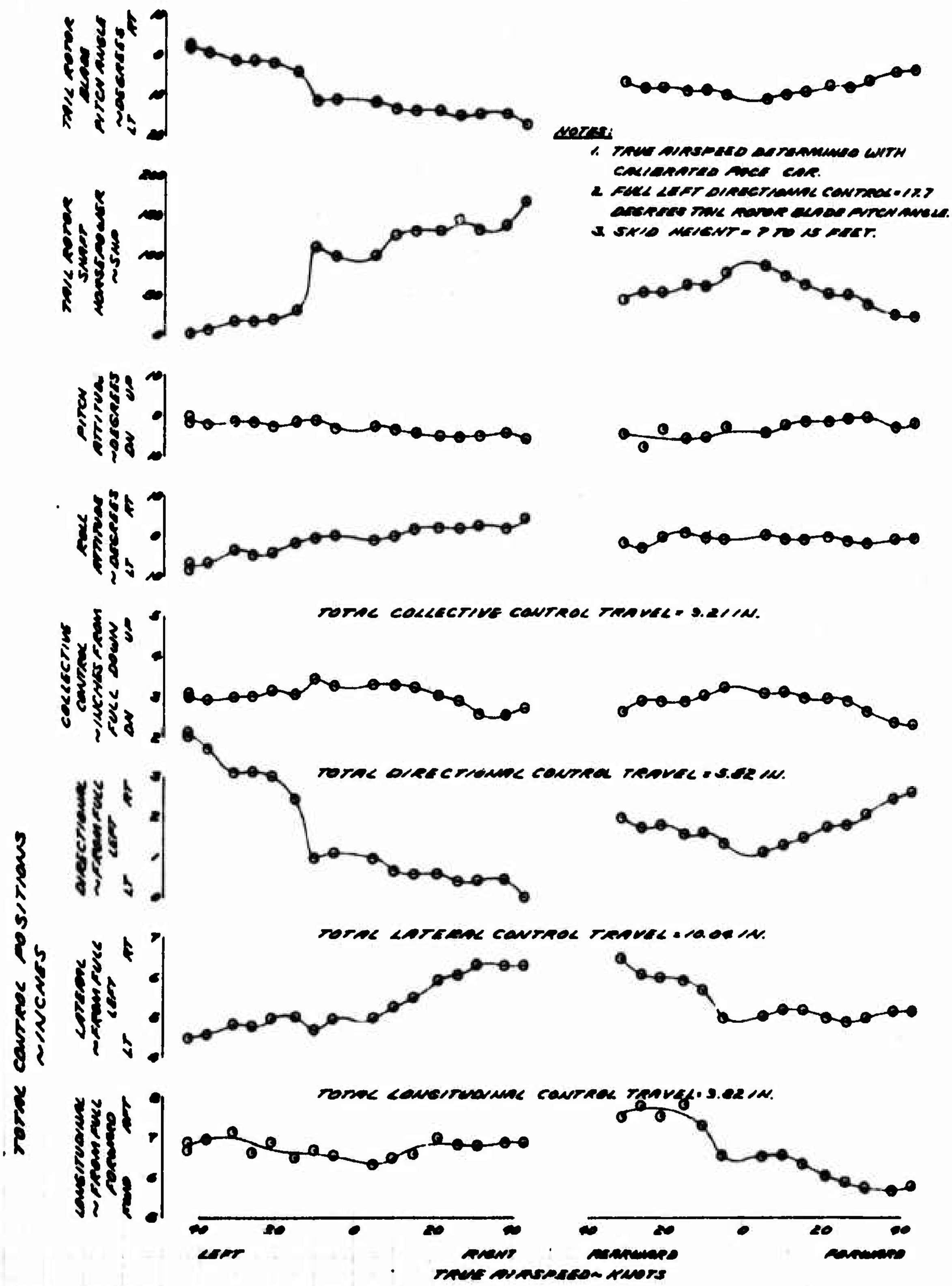


FIGURE 71
TRIMMED SIDEWARD AND REARWARD FLIGHT
AH-1G USA S/N 71-20985

| AVG GROSS WEIGHT (LB) | AVG DENSITY ALTITUDE (FT) | AVG OAT (°C) | AVG CG LOCATION (IN.) | AVG ROTOR SPEED (RPM) | AVG $C_T$ | CONFIG |
| --- | --- | --- | --- | --- | --- | --- |
| 8340 | 5360 | 12.5 | 194.9 | 326 | .004829 | HOG |

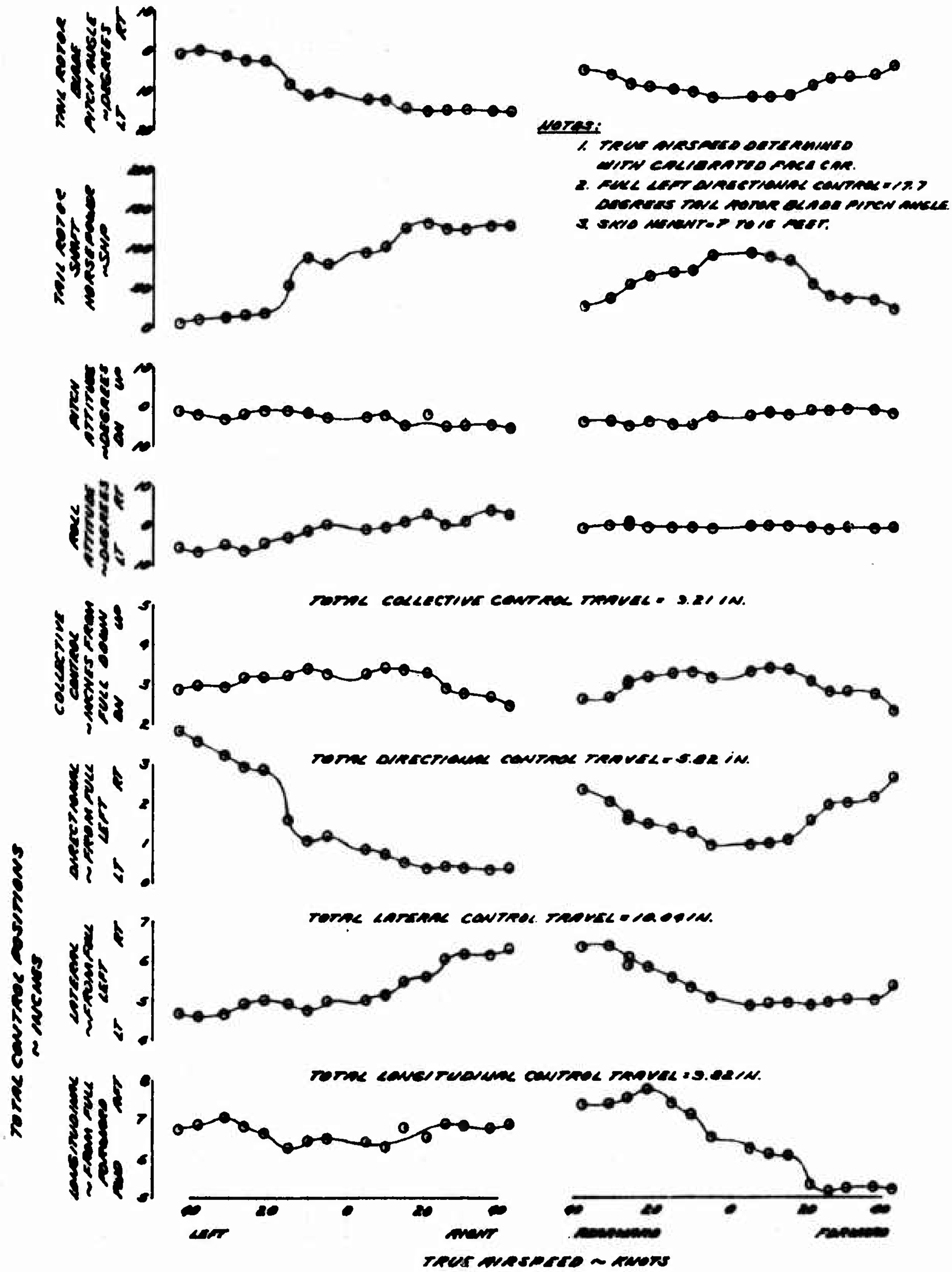


FIGURE 72

TRIMMED SIDEWARD AND REARWARD FLIGHT

AH-1G USA S/N 71-20985

| AVG GROSS WEIGHT (LB) | AVG DENSITY ALTITUDE (FT) | AVG OAT (°C) | AVG CG LOCATION (IN.) | AVG ROTOR SPEED (RPM) | AVG $C_T$ | CONFIG |
|---|---|---|---|---|---|---|
| 8060 | 4000 | 10.0 | 194.3 | 324 | .006593 | HOG |

NOTES:

1. TRUE AIRSPEED DETERMINED WITH CALIBRATED PACE CAR.
2. FULL LEFT DIRECTIONAL CONTROL = 12.7 DEGREES TAIL ROTOR BLADE PITCH ANGLE.
3. SKID HEIGHT = 7 TO 15 FEET.

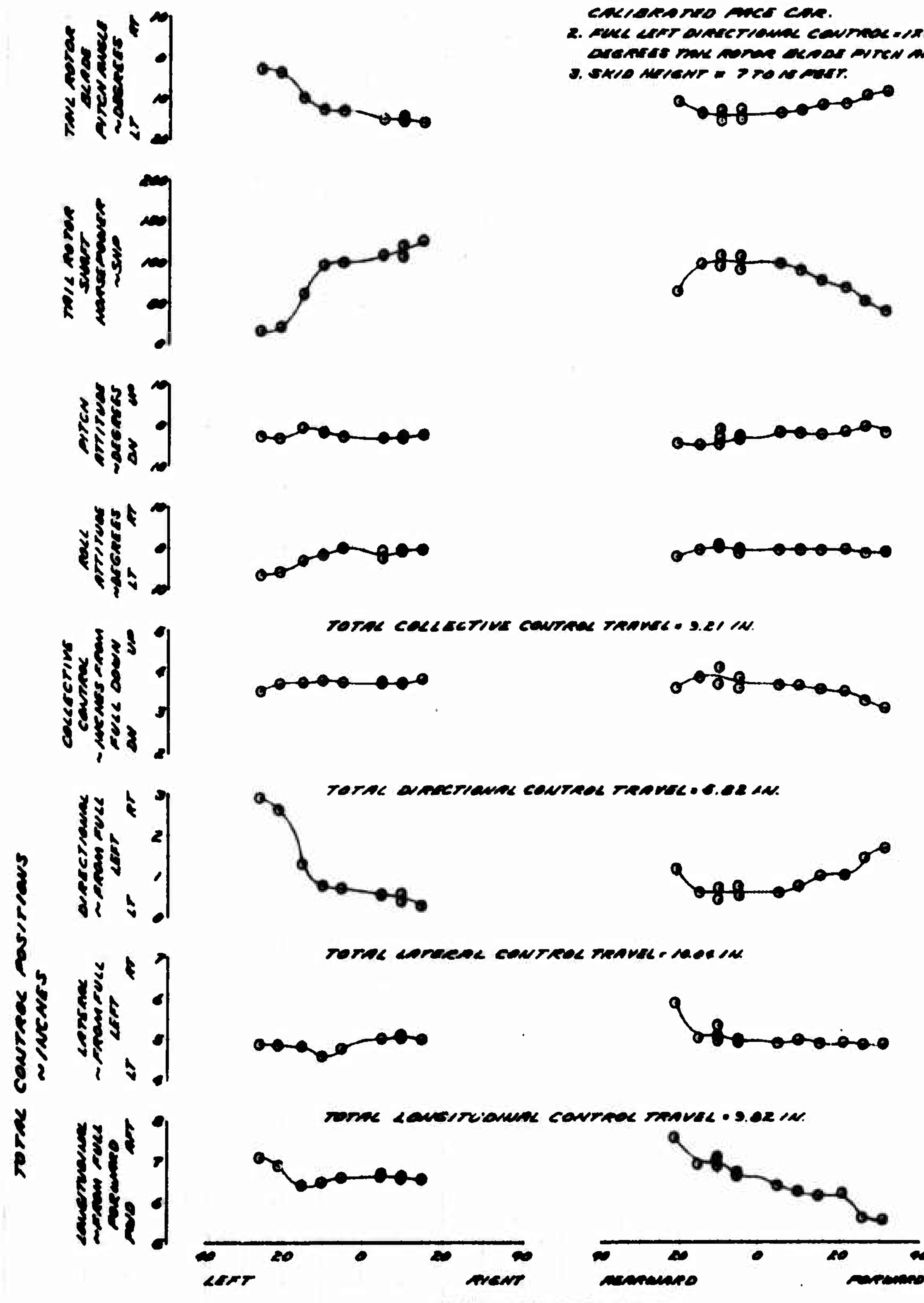


FIGURE 73

TRIMMED SIDEWARD AND REARWARD FLIGHT

AH-1G USA S/N 71-20985

| AVG GROSS WEIGHT (LB) | AVG DENSITY ALTITUDE (FT) | AVG OAT (°C) | AVG CG LOCATION (IN) | AVG ROTOR SPEED (RPM) | AVG $C_T$ | CONFIG |
|---|---|---|---|---|---|---|
| 8090 | 10880 | 8.6 | 193.7 | 324 | .005832 | HOG |

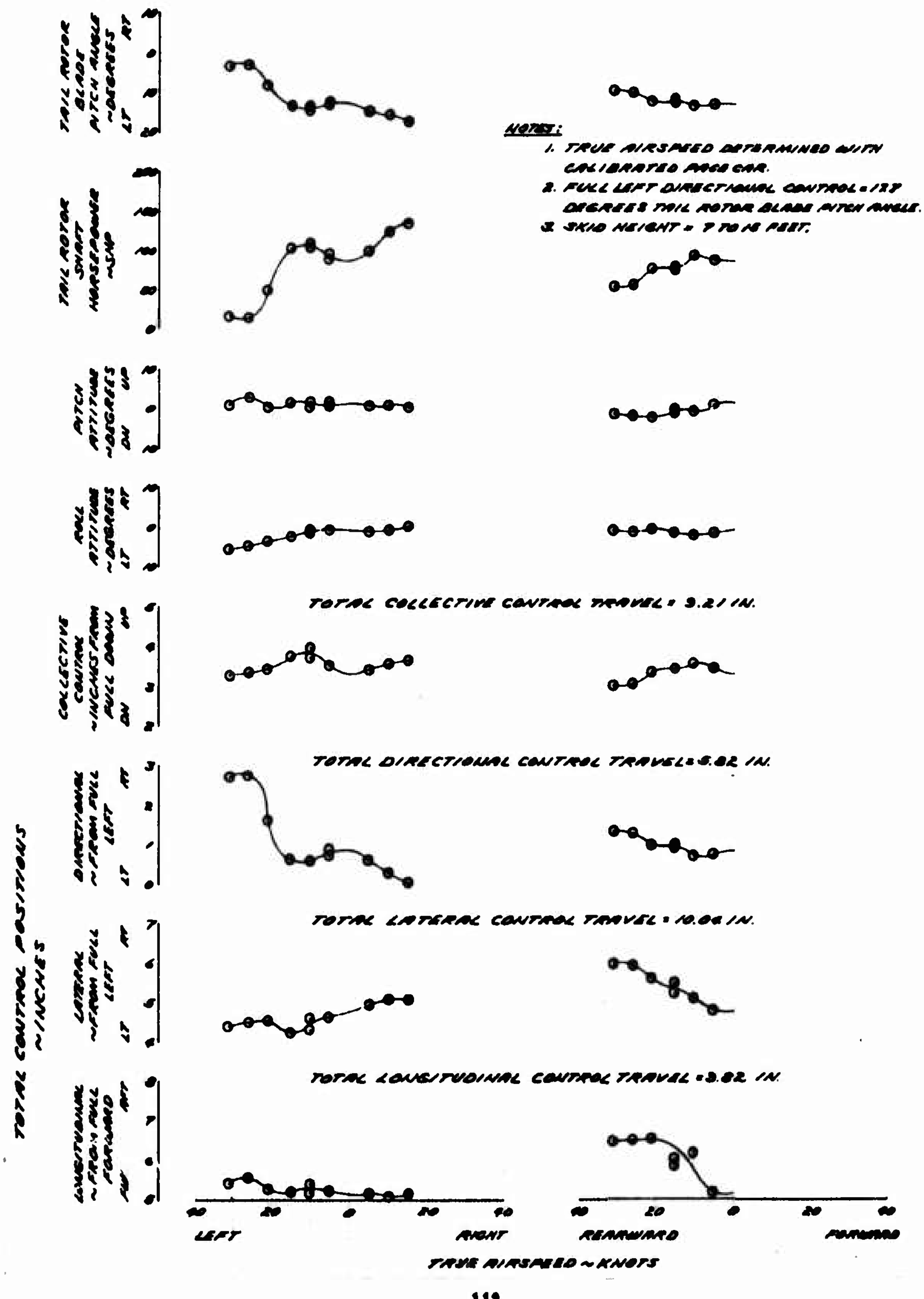


FIGURE 79

**SUMMARY OF AIRCRAFT RESPONSE FOLLOWING A SIMULATED ENGINE FAILURE**

**AH-1G USA S/N 71-20985**

| SYMBOL | FLIGHT CONDITION | AVG GROSS WEIGHT (LB) | AVG DENSITY ALTITUDE (FT) | AVG OAT (°C) | AVG CG LOCATION (IN) | AVG ROTOR SPEED (RPM) | AVG $C_T$ | CONFIG |
|---|---|---|---|---|---|---|---|---|
| ○ | LEVEL | 8600 | 4960 | 20.6 | 199.4 | 324 | .004960 | HOG |
| □ | CLIMB | 8480 | 4800 | 20.6 | 199.4 | 324 | .004868 | HOG |
| △ | DESCENT | 8450 | 4980 | 20.0 | 199.4 | 324 | .004867 | HOG |

NOTES:

1. OPEN SYMBOLS DENOTE SCAS ON.
2. SOLID SYMBOLS DENOTE SCAS OFF.

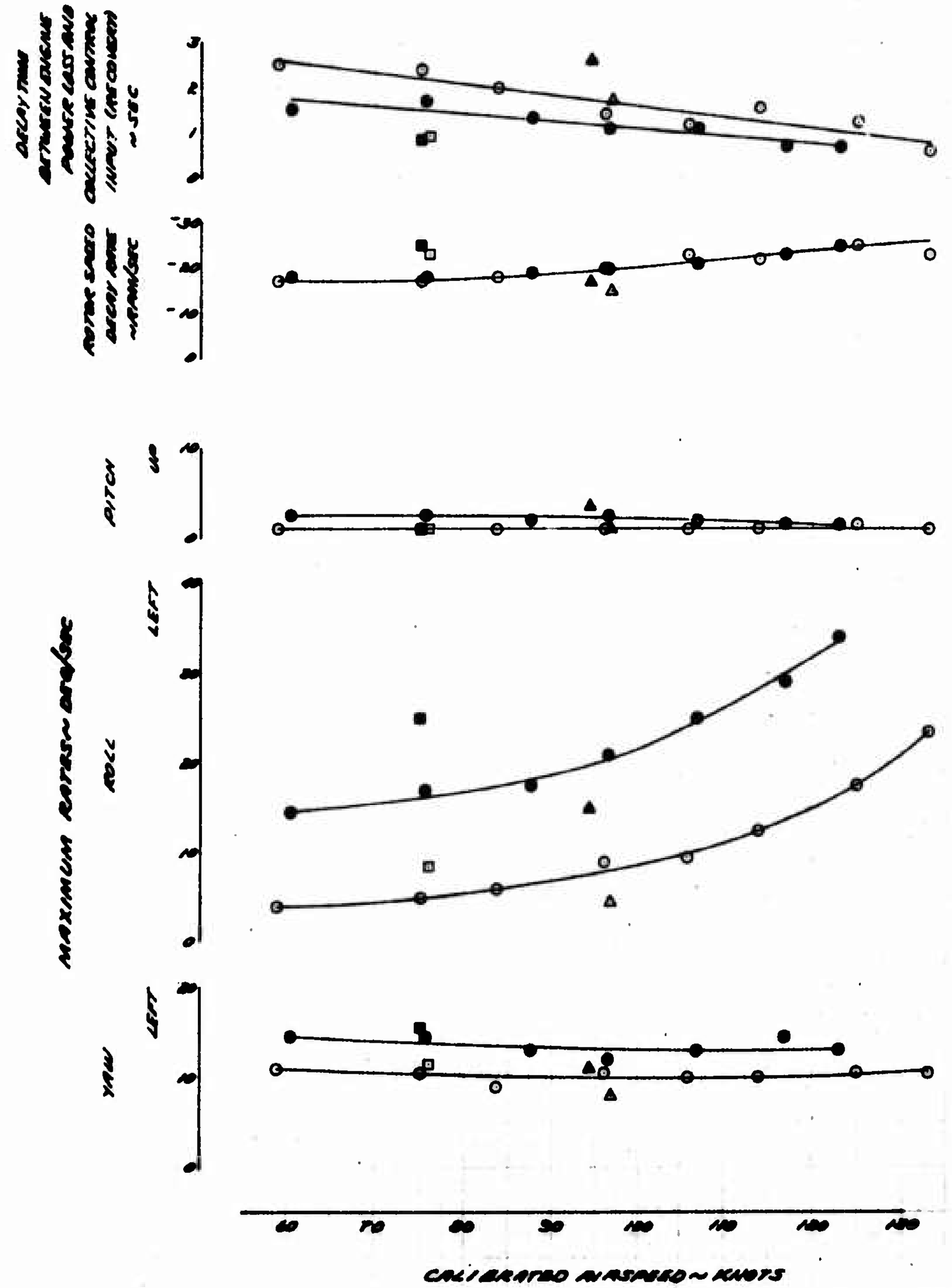


FIGURE 75

**AIRCRAFT RESPONSE FOLLOWING A SIMULATED ENGINE FAILURE**

AH-1G USA S/N 71-20985

| FLIGHT CONDITION | GROSS WEIGHT (LB) | INITIAL DENSITY ALTITUDE (FT) | OAT (°C) | CG LOCATION (IN) | INITIAL ROTOR SPEED (RPM) | INITIAL $C_T$ | TRIM AIRSPEED (KCAS) | INITIAL ENGINE TORQUE (PSI) | CONFIGURATION |
|---|---|---|---|---|---|---|---|---|---|
| LEVEL | 8580 | 4920 | 21.0 | 193.5 | 324 | .004933 | 126 | 39 | HOG |

NOTE:
SCAS ON

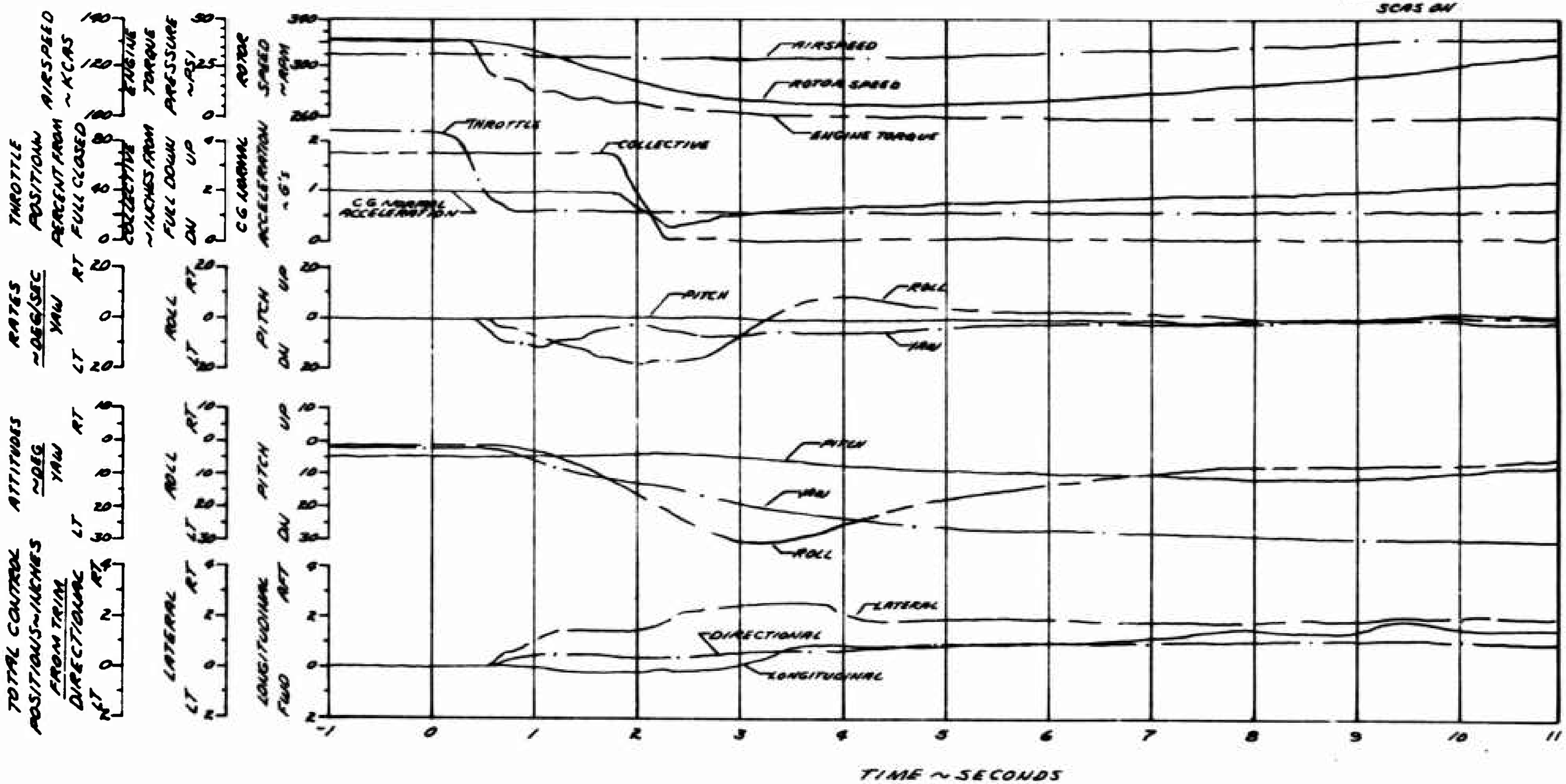


FIGURE 76

**AIRCRAFT RESPONSE FOLLOWING A SIMULATED ENGINE FAILURE**

AH-1G USA S/N 71-20985

| FLIGHT CONDITION | GROSS WEIGHT (LB) | INITIAL DENSITY ALTITUDE (FT) | OAT (°C) | CG LOCATION (IN) | INITIAL ROTOR SPEED (RPM) | INITIAL $C_T$ | TRIM AIRSPEED (KCAS) | INITIAL ENGINE TORQUE (PSI) | CONFIGURATION |
|---|---|---|---|---|---|---|---|---|---|
| | 8670 | 5020 | 13.0 | 133.4 | 324 | .004884 | 123 | 38 | HOG |

NOTE: SCAS OFF